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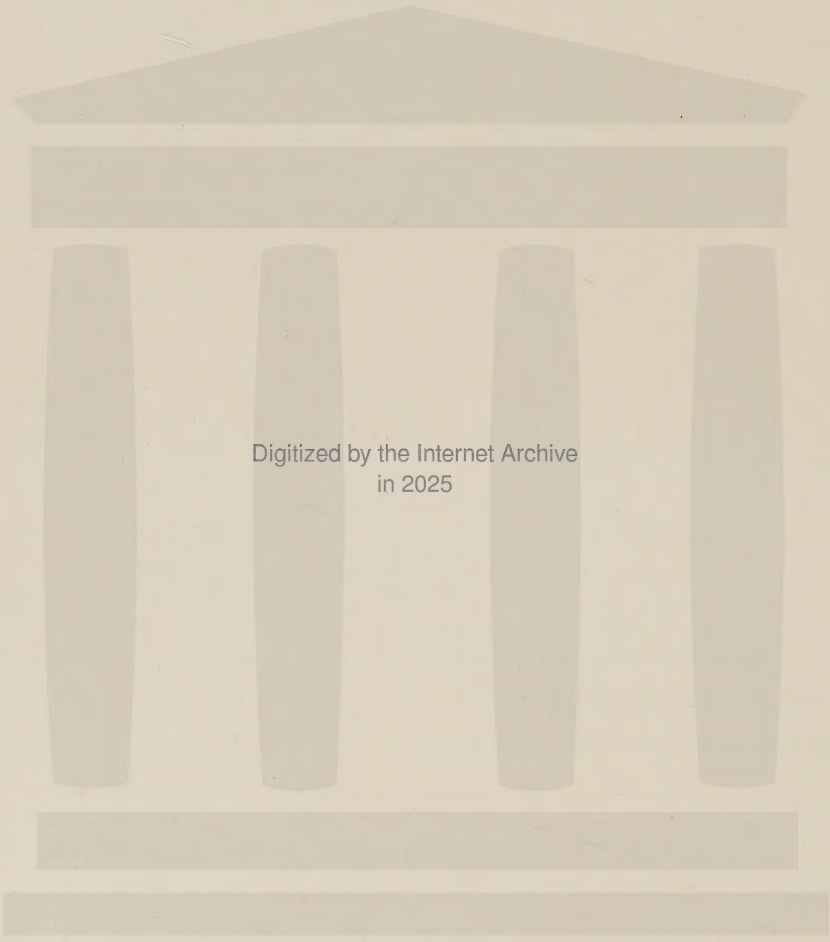

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CANADIAN JOURNAL OF AGRICULTURAL SCIENCE

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VOLUME 36 NOVEMBER-DECEMBER, 1956 No. 6

LEAF MEASUREMENTS AS A MEANS OF IDENTIFICATION OF PEACH VARIETIES IN NURSERY TREES[1]

K. Lapins and C. A. Hornby[2]

Canada Department of Agriculture, Summerland, B.C., and University of British Columbia, Vancouver, B.C.

[Received for publication May 31, 1956]

ABSTRACT

Ten different measurements or counts were made on leaf samples of five peach varieties in six locations over 3 years with the object of testing the possibility of identifying varieties in the nursery. Of the ten leaf-measurements, length of blade, width of blade, base angle, apex angle, and length of petiole, showed higher discriminative values than the other measurements under test. Measurements assisted considerably the visual method of identification. However, none of these measurements alone made it possible to distinguish between certain varieties that were very similar in their leaf characteristics. Large leaves from the middle portion of the central shoot of the nursery tree gave the most reliable samples.

INTRODUCTION

In the classification of populations and identification of individuals, qualitative characters with discontinuous variation are used wherever possible. Varietal identification of young peach trees by vegetative growth in the nursery presents great difficulties because the trees show very few qualitative characters such as the absence or presence of leaf glands and the type of gland. Many of the foliage and twig characters, such as colour, pubescence, wrinkling of leaves, that are useful in identifying varieties of most fruit trees, usually fail to differentiate peach varieties in nursery trees. This lack of sharply contrasting characters for identification by superficial inspection led to counts and measurements of various morphological characters of the peach leaf.

The primary objective of the studies was to ascertain the extent to which identification of peach varieties in the nursery is possible by means of leaf measurements. The work was directed mainly to two practical problems: (*a*) to select those morphological leaf characters which are most useful in differentiating the varieties, and (*b*) to determine which zone of the tree gives the most characteristic leaves.

[1]Joint Contribution No. 872 from Horticulture Division, Experimental Farms Service, Department of Agriculture, Ottawa, and Division of Plant Science, University of British Columbia, Vancouver.

[2]Respectively, Agricultural Research Officer and Associate Professor of Horticulture.

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REVIEW OF LITERATURE

The first attempts to classify peach varieties by vegetative characters were based on the type of leaf glands. Gregory (4), Upshall (11, 12), and workers of the Ohio Agricultural Experiment Station (9) were able to classify peach varieties into three distinct groups: (*a*) varieties without glands; (*b*) varieties with globular glands; and (*c*) varieties with reniform glands. Connors (2) found a correlation between the type of gland and the character of the leaf margin, thus introducing another reliable character of classification. Unfortunately, the application of these characters is very limited now because most peach varieties grown commercially on the American continent have reniform glands. Similarly, some decades ago colour of leaf midrib—yellow versus white—was considered a convenient means of classification of peach varieties (1, 12). However, this character is of little use because it is associated with white-flesh varieties which are not popular at the present time.

Leaf measurements have been employed as a means of identification of peach varieties in orchards by workers of the New Jersey Agricultural Experiment Station. Sefick and Blake (10) made various measurements on leaves of orchard trees and classified varieties into four groups on the basis of these measurements and certain visual observations. Meader and Blake (6, 7) measured leaves collected in widely separated orchards and found that differences in varietal leaf-blade conformation were slight. The data as obtained from orchard trees could not be applied directly to nursery trees.

MATERIALS AND METHODS

Studies of Leaf Characters

Leaf material was collected in five commercial tree fruit nurseries in 1951, 1952 and 1953. The nurseries were the same each year, except that location BC was substituted for location E in 1952 and 1953. This change was necessary because nurseries could be used only when they had a good stand of trees of the varieties under test. Of the five nurseries, two (K and S) were located in the Okanagan Valley and three (M, R and BC or E) in the Lower Mainland of British Columbia. They represented diverse climatic and soil conditions, thus providing information about the range of variation of variety due to location and season. Five peach varieties—Elberta, Spotlight, Valiant, Vedette and Veteran—were selected for the studies.

Leaf samples were collected during the second part of July. The samples were taken from one zone of the tree, viz. between 45 cm. and 60 cm. from the ground. Large, well developed, undamaged leaves were selected, and one leaf only was taken from each tree sampled. The field sample consisted of 30 leaves, but only 20 leaves were retained in the laboratory after eliminating those showing minor defects. This 20-leaf group was considered to be a practical sample size and was much larger than that used by other workers. In New Jersey, Sefick and Blake (10) measured 5 to 6 leaves, and in later experiments Meader and Blake (7) used 10 leaves.

The following measurements and counts were taken:

1. Length of leaf blade, in cm.
2. Width of leaf blade, expressed as percentage of length
3. Distance from base to the point of maximum width of blade, expressed as percentage of length
4. Base angle, measured at 1.5 cm. from base of leaf blade
5. Apex angle, maximum, in degrees
6. Apex angle, measured at 3 cm. from leaf tip, in degrees
7. Length of petiole, expressed as percentage of length of leaf blade
8. Length of petiole, in mm.
9. Glands, total (on petiole and blade)
10. Glands on petiole.

Leaf glands were counted on fresh leaves, but measurements were made on the pressed and dried material. The heavy twisting, folding and crinkling of the fresh peach leaves made it difficult to obtain accurate measurements. It was considered that the error introduced by shrinkage of leaves was smaller than that by measuring fresh peach leaves.

All linear measurements were made by placing the leaf on a sheet of paper squared in millimeters. The base angle at 1.5 cm. and apex angle at 3 cm. were measured, using a foliarmetic gauge similar to that constructed by Meader and Blake (8). Since the sample leaves to be measured were larger than those used by Meader and Blake, the gauge was altered by adapting it for measurements of the angles at slightly greater distances from the base and tip of the leaf. Maximum apex angle was measured by placing the leaf on a protractor and readings were made at the points where the outline of the leaf apex changed from a straight or convex to a concave line.

In all, 23,960 measurements were made. The data were analysed to ascertain the relative value of the characters studied for variety identification. Preliminary analyses of variance estimated the variation between varieties at each location, in each year, and for each of the ten characters. The F values for variation between varieties were used as the main criteria for the relative value of a character for identification purposes. The F value was based on a comparison of a variation between 20-leaf samples (which is due to variety differences) with that within 20-leaf samples (which is uncontrollable, thus an error). In certain instances, individual analyses were grouped together. For doing so, corresponding sums of squares and degrees of freedom from each location were added. Average mean-squares were obtained for variation both between and within varieties. From there, a pooled F value was calculated and taken to represent the character. Additional information on the discriminatory value of the individual characters was obtained from coefficients of variability and also correlation coefficients calculated from some of the data.

Four of the characters (Numbers 3, 6, 8 and 10 of the above list) appeared to have little reliability for identification and were not used in further work. Number of total leaf glands showed promise as a differentiating character, but it was observed for one year only.

Five characters (Numbers 1, 2, 4, 5 and 7 in the above list) were observed for 3 years, and an analysis of variance was made for the combined data. Each variety in each location for each year was considered to be a

plot giving an intended total of 75 plots to the experiment (5 varieties, 5 locations, 3 years). The 20-leaf averages were used as basic figures in these analyses.

When combining the 3-year results it was recognized that normal procedure in handling nursery stock posed a problem because the experimental block in a given nursery was different each year. This variability within a nursery might result in unduly large effects of location, year and their interaction. Since each nursery was relatively uniform for soil type and cultural practices, the combining of data was believed to be justified.

There were six of the 75 plot means missing, two of Spotlight and one from each of the other four varieties. The first analyses were made without substitutions for these means. Then dummy values for the missing plots were estimated by Yates' (13) procedure, and further analyses were made using these estimates. In comparing the results of the analysis using (*a*) data with 6 plots missing and (*b*) data with missing plot values substituted, it was apparent that corrected variety means differed very slightly from those calculated without missing plot values, and the F values were only slightly higher after missing values had been used.

Bartlett's test of homogeneity was applied to 1953 data and the result justified combining the data from the five locations.

Studies of Leaf Sampling Zones

A nursery planting was maintained at the Experimental Farm, Summerland, B.C., in 1952 and 1953, for use in determining the zone of the tree that would give the most reliable sample. The same varieties were used as in the leaf-character studies.

The nursery trees were pruned in summer by breaking out all the side shoots up to 55 cm. from the ground. All side branches above 55 cm. were allowed to develop.

For the purpose of collecting leaf material, the trees were divided into 7 zones (see Figure 1):

Zone 1: The 7th to 11th leaves from the ground
Zone 2: The 1st to 5th leaves from the 55 cm. point downwards
Zone 3: Leaves at the 1st to 10th side branches
Zone 3a: Leaves at the 11th to 15th side branches
Zone 4: The 1st to 5th leaves above the highest side branch
Zone 5: Leaves from the middle portion of lower (1st to 10th) side branches
Zone 6: 3rd to 7th leaves from the tip of lower side branches.

Samples for each zone were collected each year except that samples were taken from Zone 6 in 1951 only and from Zone 3a in 1952 only.

Leaf samples from the different zones were collected as they developed in the period from July to September. The procedures for picking samples, measuring leaves and evaluating data for the zonal studies were generally the same as for the leaf character studies.

RESULTS

Studies of Leaf Characters

In the course of the work, four measurements proved to have little discriminatory value. These characters, distance from base to the point

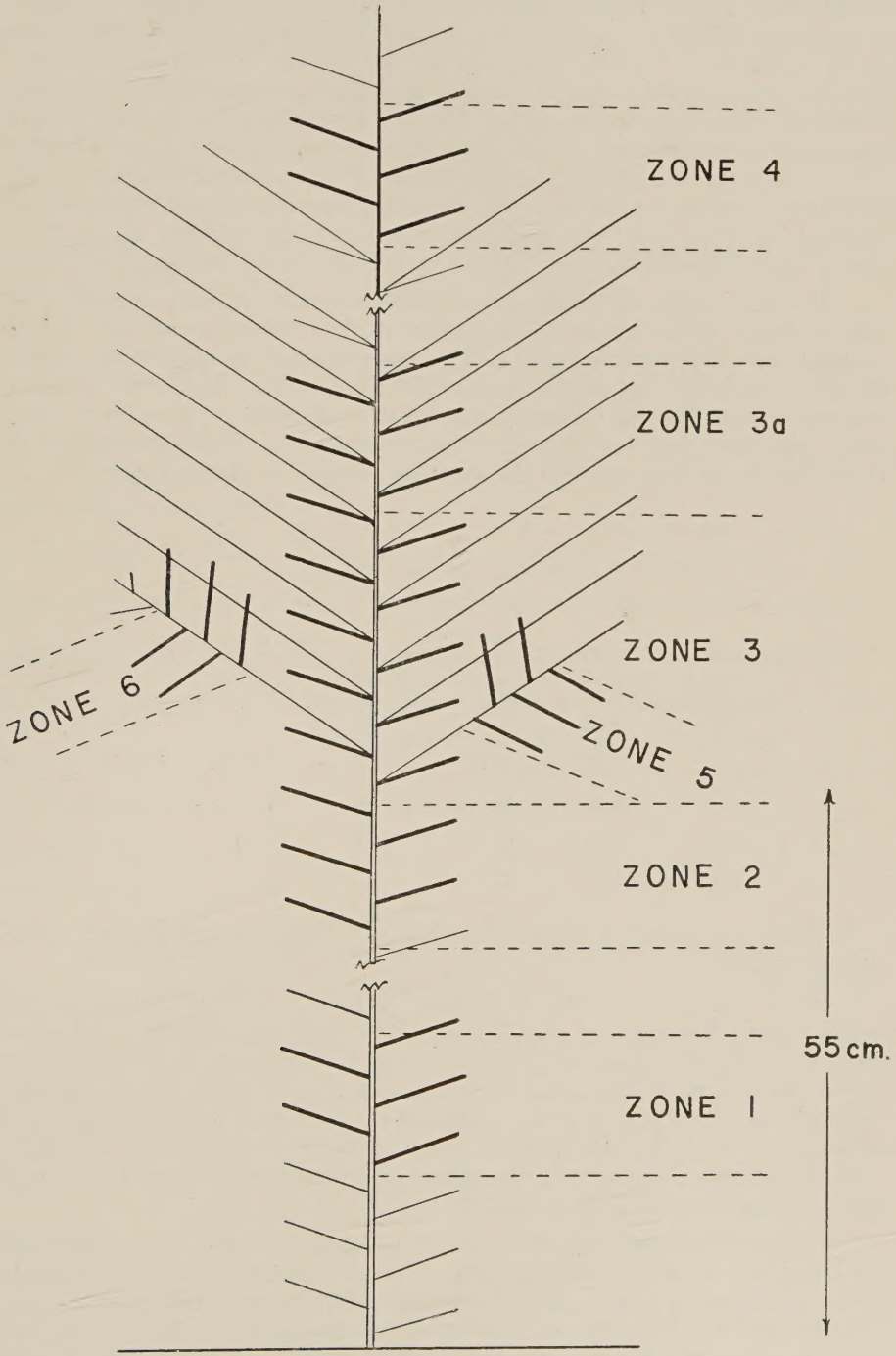

FIGURE 1. Diagram to show division of a peach tree into zones.

of maximum width of blade, apex angle at 3 cm. from tip, length of petiole in mm. and glands on petiole, were discarded as being too variable for use in identification. Number of glands per leaf was determined on one year's samples only and the value of this leaf character cannot be fully estimated. Five leaf characters, length of leaf blade, width of leaf blade, base angle, maximum apex angle and length of petiole expressed as percentage of length of leaf blade, proved to have greater value for identification purposes than the other characters observed. Of the latter five characters, width of leaf blade, base angle and apex angle were also used by workers of the New Jersey Experiment Station (6, 7, 10) in variety studies in bearing peach trees.

The data concerned with the above five characters were combined in one analysis of variance. The means of the measurements of 20-leaf samples were the variates used in the analyses of data combining effects of variety, location and year on each of five charactters. The total variation was partitioned for the following sources of variance—varieties, locations, years and their first and second order interactions. The components of these sources are expressed in the symbols as used by Kempthorne (5).

a = No. of locations = 5

b = No. of years = 3

c = No. of varieties = 5

Varieties or V	$\sigma^2 + [a\sigma^2_{vy}] + [b\sigma^2_{vl}] + \frac{ab}{c-1}\Sigma(v_k - \bar{v})^2$
Locations or L	$\sigma^2 + [b\sigma^2_{vl}] + c\sigma^2_{ly} + bc\sigma^2_{l}$
Years or Y	$\sigma^2 + [a\sigma^2_{vy}] + c\sigma^2_{ly} + ac\sigma^2_{y}$
V x L	$\sigma^2 + [b\sigma^2_{vl}]$
V x Y	$\sigma^2 + [a\sigma^2_{vy}]$
L x Y	$\sigma^2 + c\sigma^2_{ly}$
V x L x Y (Error)	σ^2

The components in square brackets are those which proved to be non-significant.

When the second order of interaction V x L x Y was used as the testing term, it was found that the effects of varieties, locations and years as well as the effect of interaction L x Y were significant for all characters while the effects of interactions V x L and V x Y were non-significant. Since the interaction L x Y was significant, it was used to test the primary effect of L which was found to be non-significant for length of leaf blade and base angle. Apparently the effect of L on these measurements was not consistent (being largely affected by Y).

Similarly, the primary effect of Y, independent of L, was calculated by using L x Y as the testing term. The primary effect of Y was found to be non-significant, except for base angle where it was highly significant. On the other hand, the primary effect of varieties was calculated, using the error V x L x Y as the testing term since the other components, V x L and V x Y, that contributed to the varietal effect were non-significant.

TABLE 1.—SUMMARY OF THE COMBINED ANALYSES OF VARIANCE USING DATA ON PEACH LEAVES FROM 5 VARIETIES AT 5 LOCATIONS FOR 3 YEARS

Source of variation	D.F.	M. S.				
		Length	Width	Base angle	Apex angle	Petiole
Total	68					
Varieties (V)	4	4.2618**	82.0275**	750.3475**	38.8150**	3.7228**
Locations (L)	4	4.7766	17.5725**	105.6375	47.1025**	2.9048**
Years (Y)	2	1.7732	2.6450	560.3450**	3.0250	0.1625
V x L	16	0.1567	0.4487	3.8212	0.6531	0.1503
V x Y	8	0.1067	0.6675	4.0975	0.8500	0.0591
L x Y	8	2.7533**	1.1050*	35.6375**	3.2850**	0.3363**
V x L x Y	26	0.1222	0.4615	3.0715	0.6981	0.0768

* Significant and ** highly significant differences.

TABLE 2.—VARIETY MEANS FOR 5 LEAF CHARACTERS FROM DATA FOR 5 LOCATIONS AND 3 YEARS COMBINED

Leaf characters	Varieties					L.S.D. 1%
	Elberta	Vedette	Veteran	Spotlight	Valiant	
Length (L), cm.	17.2	16.5	17.8	17.8	17.5	0.4
Width, in % of L	28.3	28.7	26.9	24.1	23.7	0.7
Base angle, degrees	92.9	90.2	91.1	82.5	76.1	1.8
Apex angle, degrees	31.5	31.6	29.2	28.0	28.8	0.8
Petiole, in % of L	4.5	4.6	4.1	4.7	5.5	0.3

A summary of the anlyses of variance for the five characters is given in Table 1. The means of measurements for varieties, locations and years are shown in Tables 2, 3 and 4, respectively.

The important conclusion, drawn from the analysis, is that the effect of varieties was significant on all characters. Varietal effect stood out above all other factors. The primary effects of location and of season may or may not be significant, while the effect of location-season interaction tended to be significant. Location-year interaction was high for all characters. Under the conditions of the present experiment the interaction effects could be attributed mainly to the fact that the actual location of trees in the same nursery was different each year as previously indicated.

The differences between means of each two varieties for each character were compared and those differences which were highly significant are shown in Table 5. Disregarding the combinations of varieties which usually show significant differences in several characters, interest is mainly attached to those varieties which may differ in one or two characters only.

TABLE 3.—LOCATION MEANS FOR 5 LEAF CHARACTERS FROM DATA FOR 5 VARIETIES AND 3 YEARS COMBINED

Leaf characters	Locations					L.S.D. 1%
	BC and E	M	R	K	S	
Length (L), cm.	16.8	18.3	17.4	17.4	17.0	2.0
Width, in % of L	26.1	25.3	25.4	27.6	27.4	1.3
Base angle, degrees	88.0	82.9	84.5	88.8	88.5	8.3
Apex angle, degrees	28.4	28.4	28.8	32.0	31.5	2.2
Petiole, in % of L	4.9	5.2	4.9	4.2	4.3	0.7

TABLE 4.—YEAR MEANS FOR 5 LEAF CHARACTERS FROM DATA FOR 5 VARIETIES AND 5 LOCATIONS COMBINED

Leaf characters	Years			L.S.D. 1%
	1951	1952	1953	
Length (L), cm.	17.1	17.4	17.6	1.6
Width, in % of L	26.3	26.0	26.4	1.0
Base angle, degrees	91.9	83.1	84.6	5.7
Apex angle, degrees	30.2	29.5	29.8	1.7
Petiole, in % of L	4.7	4.6	4.7	0.5

According to Table 5, Elberta and Vedette can be expected to differ significantly in length of the blade and in base angle. However, reference to the separate analyses of variance at each location and year (not presented here) showed that out of 16 comparisons between these two varieties, the differences in length of blade were significant or highly significant in 9 instances but the differences in base angle were significant in 6 cases only. The situation is similar in the case of differences between Valiant and Spotlight. According to Table 5, these varieties can be expected to show significant differences in base angle and in length of petiole. In the individual observations, however, out of 15 comparisons, the differences were significant in 12 instances in base angle and in 10 instances in length of petiole.

In order to increase the chance of obtaining significant differences between individual samples of similar varieties, the sample size should be increased, possibly to 40 or 50 leaves. These examples also show that any single character may not enable one to distinguish between some varieties unless the size of sample is larger than practicable.

TABLE 5.—HIGHLY SIGNIFICANT DIFFERENCES BETWEEN VARIETY MEANS WERE SHOWN IN THE CHARACTERS LISTED FOR EACH TWO VARIETIES

	Vedette	Veteran	Spotlight	Valiant
Elberta	Length of blade Base angle	Length of blade Width of blade Base angle Apex angle Length of petiole	Length of blade Width of blade Base angle Apex angle	Width of blade Base angle Apex angle Length of petiole
Vedette		Length of blade Width of blade Apex angle Length of petiole	Length of blade Width of blade Base angle Apex angle	Length of blade Width of blade Base angle Apex angle Length of petiole
Veteran			Width of blade Base angle Apex angle Length of petiole	Width of blade Base angle Length of petiole
Spotlight				Base angle Length of petiole

Table 5 illustrates the grouping of varieties, with Vedette and Elberta at one end and Valiant and Spotlight at the other. A polygonal graph (Figure 2) shows this grouping very clearly. As indicated by Davidson (3), a polygonal graph can be successfully used to supply the following important information: the variety means, the range of variation in the character, the correlation between characters and the validity of a character in distinguishing between varieties.

Studies of Leaf Sampling Zones

Observations at the Experimental Farm were made to determine: (1) whether the zone of the tree could have a significant effect on the variability in leaf measurements, and (2) if necessary, which zone would

TABLE 6.—ANALYSIS OF VARIANCE OF DATA FROM LEAF SAMPLES FROM 5 ZONES ON YOUNG PEACH TREES

Source of variation	D.F.	M. S.					
		Length	Width	Base angle	Apex angle	Petiole	Glands
Total	49						
Varieties (V)	4	1.263*	45.127**	452.180**	23.013**	4.200*	*9.482**
Zones (Z)	4	14.041**	34.377**	198.550	39.962**	0.364	4.449
Years (Y)	1	5.545**	17.264**	118.890	0.004	0.010	0.639
V x Z	16	0.279	0.668	4.249	2.463	0.042	0.210
V x Y	4	0.521	0.762	13.700*	0.849	0.090	0.046
Z x Y	4	0.484	0.635	41.435**	0.233	0.897**	3.826**
V x Z x Y	16	0.326	0.410	3.656	1.485	0.071	0.246

* Significant and ** highly significant differences.

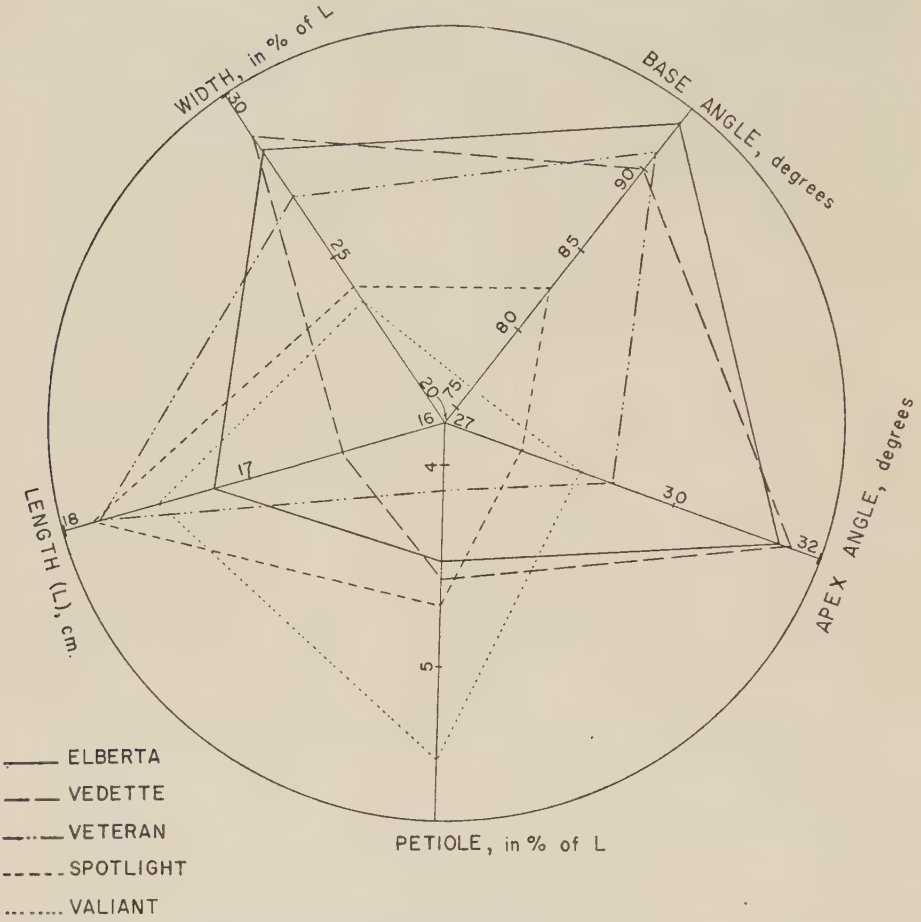

FIGURE 2. Polygonal graph showing configuration of varieties. Note the position of Valiant and Spotlight at one end of the graph.

give the most reliable sample. The methods used here were similar to those of the previous section. Total number of leaf glands per leaf was included in the characters studied.

Analysis of Variance of the Combined Data

Leaf samples were taken from 7 different zones in 2 years, as outlined previously, but only 5 zones were represented in both years. Only the data from these 5 zones were included in the analysis of combined data. Means of the 20-leaf samples were taken as basic figures of the analyses.

The analysis of combined data (Table 6) showed significant differences between varieties in all characters. The primary effect of zones showed highly significant differences in length of blade, width of blade and apex angle; while the primary effect of season showed highly significant differences only in length and width of blade. Interactions of these factors were mostly non-significant; in some characters, however, some of the zone-year interactions were highly significant, indicating that samples from the same zone may differ in different seasons. Variety-year interaction was significant for base angle data.

The important conclusion to be drawn from these analyses is that zones had significant effects on the characters of a sample.

Reliable Zones in Sampling

Since the zone affected the results of measurements, it was necessary to ascertain which zone gave the sample which best characterizes the variety and differentiates it from other varieties. The F values for variation between varieties were used as criteria for the relative usefulness of the zones. The F values from pooled analyses are given in Table 7 and their ranking in Table 8.

Table 8 shows that the Zones 4, 5 and 6 rank high in their F values and these zones should be valuable for taking leaf samples. The use of these zones, however, may be impracticable. First, weak trees may fail to develop large, normal leaves on their side branches (Zones 5 and 6). Secondly, leaves close to the tip of the main shoot (Zone 4) are frequently disfigured by mildew before they fully develop and thus are useless for identification. Zone 3a showed high F values and may be useful but its

TABLE 7.—F VALUES (FOR VARIATION BETWEEN VARIETIES) SHOWING EFFECT OF ZONES OF THE TREE ON LEAF CHARACTERS

Leaf characters	Zones						
	1	2	3	3a	4	5	6
Length (L), cm.	3.63	3.19	3.16	96.00	32.25	9.99	14.38
Width, in % of L	51.87	37.39	69.87	47.17	64.01	61.40	47.86
Base angle	28.61	34.15	54.24	43.85	58.87	64.03	70.28
Apex angle, max.	6.45	8.88	18.32	20.70	39.31	15.23	25.16
Petiole, in % of L	11.29	13.63	20.55	16.46	21.40	21.35	23.68
Glands, total	13.71	9.82	12.61	12.89	14.27	15.46	11.09

TABLE 8.—RANKING OF F VALUES SHOWING EFFECT OF ZONES OF THE TREE ON LEAF CHARACTERS

Leaf characters	Zones						
	1	2	3	3a	4	5	6
Length (L), cm.	5	6	7	1	2	4	3
Width, in % of L	4	7	1	6	2	3	5
Base angle	7	6	4	5	3	2	1
Apex angle, max.	7	6	4	3	1	5	2
Petiole in % of L	7	6	4	5	2	3	1
Glands, total	3	7	5	4	2	1	6

value could not be fully estimated as the data represented results from one season only. Zone 3 appears to be the most promising since it showed reasonably high F values and the leaves from this zone are normally well developed. The leaves of this zone are from the main stem, at the lowest ten side branches (see Figure 1).

The considerable variation in size and shape of the leaves taken from different zones is illustrated in Plates I and II. The outlines of the leaves demonstrate that small leaves and those from the base of the main shoot show greatest deviation from the average shape and have little value in variety studies.

The results of the sampling studies could be summarized by stating that large, well developed leaves from the central or upper portions of the main stem of the peach tree were suitable for the investigation. Zone 3 appeared to be the most reliable as the source of leaf samples.

DISCUSSION

The main problem was to determine whether peach varieties could be identified in the nursery rows by means of leaf measurements. First, it could be asked whether identification is possible by using variety means of individual characters. Analysis of variance showed that the effect of varieties was always significant. However, this merely means that certain of the five varieties under test differ significantly, but does not exclude the possibility that other of the five varieties may not differ in any of the characters measured. In fact, the mean values of the individual samples were greatly overlapping in certain varieties, and these could not be differentiated by any of the characters under observation.

Although Table 5 lists certain discriminating characters for each two varieties, it refers to the results that could be expected if a similar 3-year experiment were repeated. Individual 20-leaf samples, on the other hand, as indicated above, may not differentiate certain similar varieties.

The chances of correct identification might be increased by taking larger samples. In many instances a 20-leaf sample may be sufficient, but a 40- or 50-leaf sample is proposed where varieties are involved that closely resemble one another or where the growing conditions have caused great variation in plant growth.

Trees grown in different locations may show a great difference in absolute measurements of the leaves, but the relative standing of each variety usually remains the same. It appears that relative figures could be used, taking one variety as a standard. Results of some preliminary calculations supported this view. Of course, the relative figures could be used only if one variety in a particular location could be identified. Normally, Valiant can be successfully used as the standard.

Another possibility of increasing the chances of correct identification by the use of leaf measurements is to use all the characters simultaneously for comparison rather than taking each character singly. The merit of this method was explored by using the discriminant function analysis and the results will be reported subsequently.

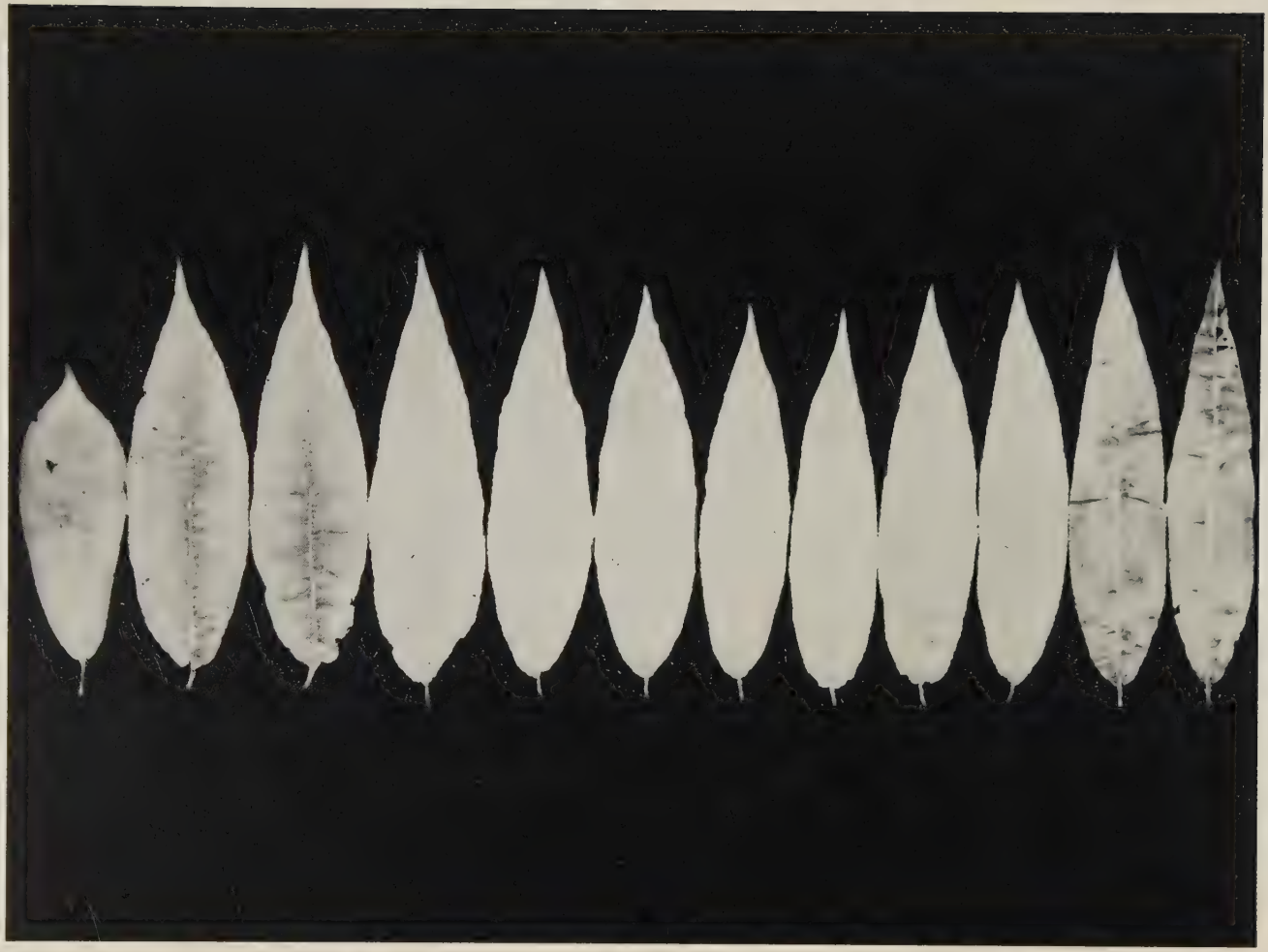

PLATE I. Leaves of Veteran. The sample comprised every fifth leaf from base (*left*) to tip (*right*) from a central shoot of a tree.

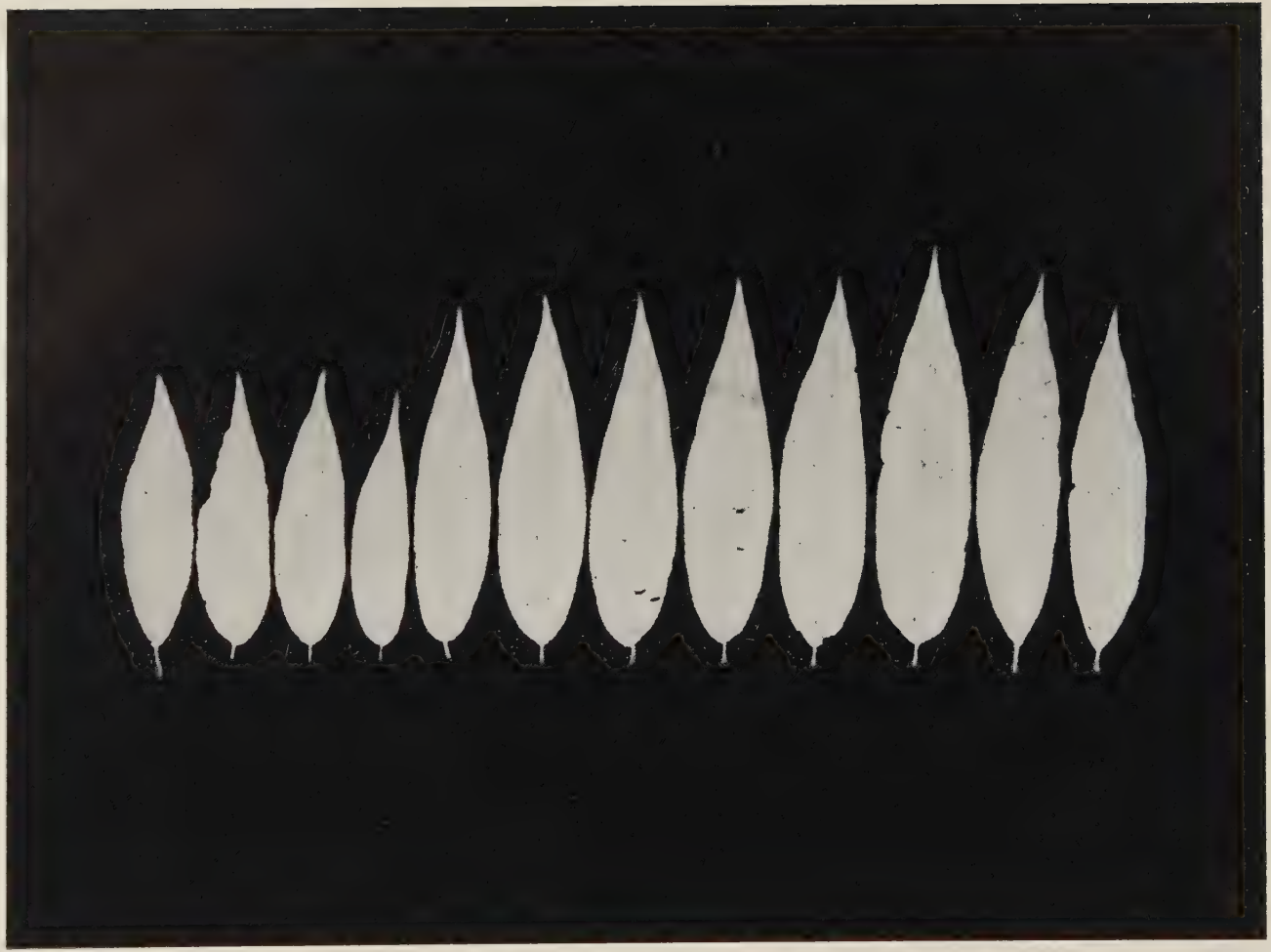

PLATE II. Leaves of Veteran. The sample comprised every third leaf from base (*left*) to tip (*right*) from a low side branch.

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SEASONAL AND REGIONAL VARIATIONS IN SOME CHEMICAL AND PHYSICAL PROPERTIES OF ALBERTA BUTTERFAT[1]

F. W. Wood

Department of Dairying, University of Alberta, Edmonton, Alberta

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ABSTRACT

Refractive indexes, iodine and Reichert-Meissl values and softening points of butterfat from seven creameries situated in northern, central and southern parts of Alberta displayed distinct seasonal and regional variations over a 2-year period. Except for the softening points no statistically significant difference was found when the variations of the 1952-53 data were compared with those of 1953-54. Both seasonal and regional fluctuations in the butterfat composition may be related in part to differing feeding practices. High refractive indexes and iodine and Reichert-Meissl values were observed during the spring and summer and low values during autumn and winter, although Lethbridge butterfats were characterized by maximum Reichert-Meissl values in November. The average monthly iodine values varied regionally. The values of the butterfat from one point, however, did not follow this pattern. Softening points were inversely correlated with iodine values ($r = -0.37$) and with Reichert-Meissl values ($r = -0.58$).

INTRODUCTION

An investigation of the body and texture characteristics of butter manufactured by the Gold'n Flow buttermaking process was initiated by a study of the seasonal and regional variations of certain chemical and physical properties of Alberta butterfats. Fluctuations of iodine and Reichert-Meissl values, refractive indexes and softening points of representative butterfats were followed over a 2-year period, because of the influence of these properties on the hardness and spreadability of butter.

METHODS

One-pound lots of butter were received weekly from seven Alberta creameries located at Bonnyville, Calgary, Coronation, Edmonton (A and B), Lethbridge and Red Deer. The investigation extended over 104 consecutive weeks, beginning April, 1952.

The butterfat was prepared for analysis by melting the butter in beakers at 50° to 60° C., and filtering the decanted liquid fat through Whatman No. 1 filter paper in an ambient atmosphere maintained at 50° C. The filtered butterfat was stored at −20° C. until tested.

Iodine (Wijs) and Reichert-Meissl values and refractive indexes were determined by the A.O.C.S. Official and Tentative Methods (1). Refractive indexes were read at 40° ±0.05° C. with a Zeiss dipping refractometer. Softening points were determined by Barnicoat's modification of the falling-ball method (2) and temperature readings were to the nearest 0.1° C. on a thermometer calibrated against a thermometer of 0.01° C. certified accuracy.

All analyses were made in duplicate. Each value in the figures or tables is based on a monthly average for 2 years and represents 8 samples (16 analyses).

[1] This study was supported as EMR Project No. 18 by Science Service, Canada Department of Agriculture, Ottawa, Canada.

RESULTS

Iodine Value

The seasonal and regional variations found for iodine values are shown in Table 1. The 1952-53 iodine values did not differ with statistical significance from those for 1953-54. The differences between sampling points, between months and between sampling points × months were statistically significant. The iodine values, indicative of the unsaturated acid content, were high during the grass feeding season, reaching their maxima in May or August-September. The autumn decline was rapid to minimum values which were attained in November-December. The iodine values of all butterfats decreased in June. The decrease was significant for all but Edmonton butterfats. The range of iodine values was greater in the Lethbridge than in the other butter fats. The seasonal flucutations in these values for the Edmonton and Lethbridge samples are compared in Figure 1.

The variations in iodine values permit the grouping of the sampling points into four regions, with the lowest and highest average values at Lethbridge and Edmonton, respectively. The remaining sampling points have intermediate average values, but they may also be grouped into two regions with Calgary and Coronation in one and Red Deer and Bonnyville in the other. The Calgary-Coronation grouping was to be expected because of similar climatic and pasture conditions, but the Bonnyville-Red Deer similarity appears anomalous from a regional point of view. Bonnyville is the northern most of the sampling points, being located approximately 200 miles northeast of Red Deer.

TABLE 1.—IODINE VALUES

	Lethbridge	Calgary	Coronation	Red Deer	Bonnyville	Edmonton A	Edmonton B	Av.
January	31.7	35.2	34.8	35.8	35.7	35.9	36.5	35.1
February	33.1	36.1	35.5	35.4	36.2	37.0	37.0	35.7
March	34.0	35.5	35.1	35.5	36.3	36.9	37.3	35.8
April	36.4	37.7	37.2	37.2	37.5	37.9	37.6	37.3
May	37.8	37.9	37.9	38.5	39.6	39.9	39.9	38.8
June	36.3	35.8	36.3	37.4	36.7	39.1	39.3	37.2
July	36.1	36.0	36.3	38.5	37.5	39.5	40.0	37.7
August	36.4	36.2	37.3	39.2	39.8	40.2	41.4	38.6
September	36.0	36.2	37.0	38.8	39.9	40.5	41.4	38.5
October	33.0	34.4	35.6	36.0	36.6	37.3	38.1	35.8
November	29.5	33.5	33.9	34.5	34.8	35.6	35.7	33.9
December	29.7	34.6	33.7	35.4	35.2	35.5	35.9	34.2
Average	34.1	35.8	35.7	36.8	37.1	37.9	38.3	

Least significant difference (L.S.D.) for months—0.89.
Least significant difference (L.S.D.) for sampling points—0.68.
Least significant difference (L.S.D.) for sampling points × months—1.21.

Refractive Index

Table 2 shows that the refractive indexes, another measure of unsaturated acids, were in general confirmatory of the iodine values. The differences between months, sampling points and sampling points × months were statistically significant. By this criterion Calgary, Coronation, Red Deer and Bonnyville may be grouped together. This difference from the iodine value grouping is small and probably of little or no practical importance.

TABLE 2.—REFRACTIVE INDEXES

	Lethbridge	Calgary	Coronation	Red Deer	Bonnyville	Edmonton A	Edmonton B	Av.
January	387*	444	467	453	463	474	484	453
February	409	461	475	456	469	488	489	464
March	426	449	465	453	467	478	489	461
April	451	488	490	490	482	491	496	484
May	484	493	495	496	509	525	526	504
June	465	459	460	478	451	499	514	475
July	471	466	465	503	478	517	536	491
August	481	491	480	514	512	541	561	511
September	472	485	477	514	530	544	560	511
October	408	465	452	471	481	502	512	470
November	339	442	442	448	461	468	481	440
December	350	437	459	458	460	474	478	445
Average	428	465	469	478	480	500	510	

* Each value to be preceded by 1.45.

L.S.D. for months—19.9.
L.S.D. for sampling points—15.2.
L.S.D. for sampling points × months—22.9.

TABLE 3.—REICHERT-MEISSL VALUES

	Lethbridge	Calgary	Coronation	Red Deer	Bonnyville	Edmonton A	Edmonton B	Av.
January	26.5	26.9	26.3	26.6	26.7	26.4	26.2	26.5
February	26.7	26.9	26.4	26.4	27.1	26.6	26.7	26.7
March	26.4	27.2	27.0	27.4	27.7	26.8	26.3	26.9
April	26.2	26.5	26.4	26.7	26.6	27.0	26.3	26.5
May	26.6	27.3	27.3	27.5	27.0	27.2	26.6	27.0
June	27.8	28.0	28.4	28.3	28.8	28.1	27.8	28.2
July	26.9	27.7	27.7	27.5	28.5	27.7	27.8	27.7
August	27.0	26.9	27.0	27.0	27.0	27.3	26.5	26.9
September	25.7	26.5	26.3	26.2	25.4	25.3	25.4	25.8
October	27.1	26.4	24.4	26.1	24.7	25.5	25.1	25.7
November	27.9	26.5	24.6	25.6	24.3	25.3	25.0	25.6
December	26.9	26.8	25.0	25.4	25.5	25.3	25.9	25.7
Average	26.8	26.9	26.5	26.7	26.6	26.5	26.3	

L.S.D. for months—0.59.
L.S.D. for sampling points × months—1.23.

Reichert-Meissl Value

The 1952-53 Reichert-Meissl values do not differ with statistical significance from those for 1953-54 and, as is to be observed in Table 3, sampling point differences are also not significant. There were, however, significant differences between months and sampling points × months. The butterfat from all sampling points exhibited peak Reichert-Meissl values in June and, except for Lethbridge butterfats, minima occurred in October to December. Lethbridge butterfat differed from the others in that the minimum value occurred in September and the maximum value in November.

Softening Point

A difference significant at the 1 per cent level was found between the softening point data of 1952-53 and that of 1953-54. There were also significant differences between months and between sampling points. As shown in Table 4, softening points reached their maxima for all sampling points in November and high levels were maintained throughout the winter. Minimum values were recorded for June. A sharp and significant drop in values was noted in Lethbridge fats during October of both years. A somewhat similar decrease took place in the butterfats from the other sampling points during September of 1953 only.

Interrelations

Inverse correlations between softening points and iodine values, and between softening points and Reichert-Meissl values, were expected and are shown in Figures 1 and 2. The correlation coefficients based on data from all sampling points were −0.37 and −0.58 respectively and both

TABLE 4.—SOFTENING POINTS

	Lethbridge	Calgary	Coronation	Red Deer	Bonnyville	Edmonton A	Edmonton B	Av.
January	32.9	33.1	33.1	33.1	33.2	32.7	33.1	33.0
February	32.6	33.1	33.0	33.1	32.9	32.8	33.2	32.9
March	32.2	33.2	32.9	32.9	32.8	32.7	33.4	32.9
April	32.6	32.8	32.8	32.9	33.1	33.0	33.5	32.9
May	32.0	32.3	32.5	32.1	32.6	33.0	32.8	32.3
June	31.9	32.0	32.1	31.7	32.5	32.1	32.0	32.0
July	32.6	32.3	32.5	32.3	32.9	32.3	32.4	32.4
August	32.8	32.7	32.7	32.3	32.9	32.5	32.6	32.6
September	32.8	32.8	32.6	32.7	32.9	32.7	32.4	32.7
October	32.5	32.8	32.9	33.2	33.2	33.0	33.1	32.9
November	33.1	33.2	33.4	33.5	33.9	33.4	33.8	33.4
December	33.1	33.1	33.4	33.4	33.3	33.3	33.5	33.3
Average	32.6	32.8	32.8	32.7	33.0	32.7	33.0	

L.S.D. for months—0.19.
L.S.D. for sampling points—0.14.

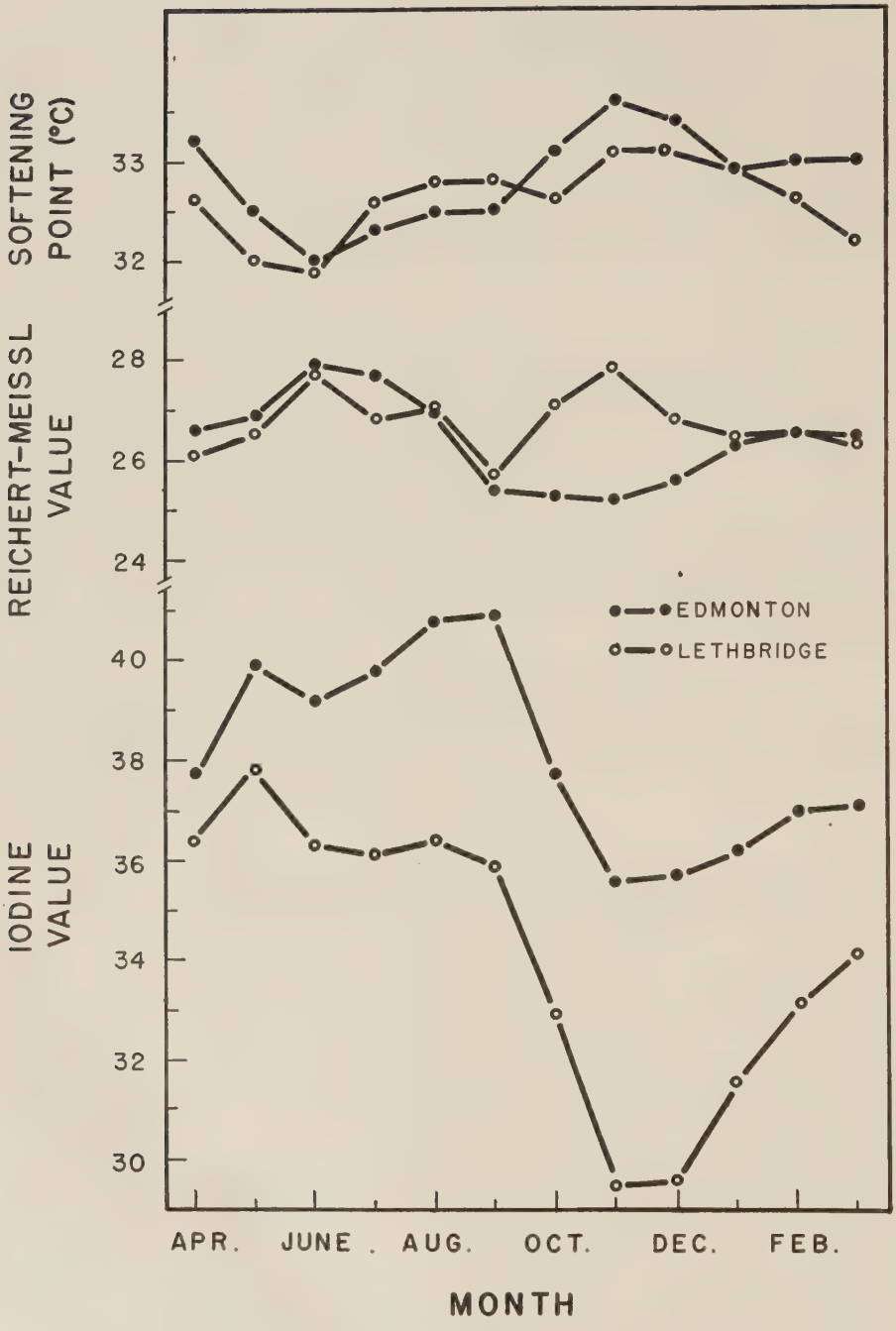

FIGURE 1. Softening points and iodine and Reichert-Meissl values for Edmonton and Lethbridge.

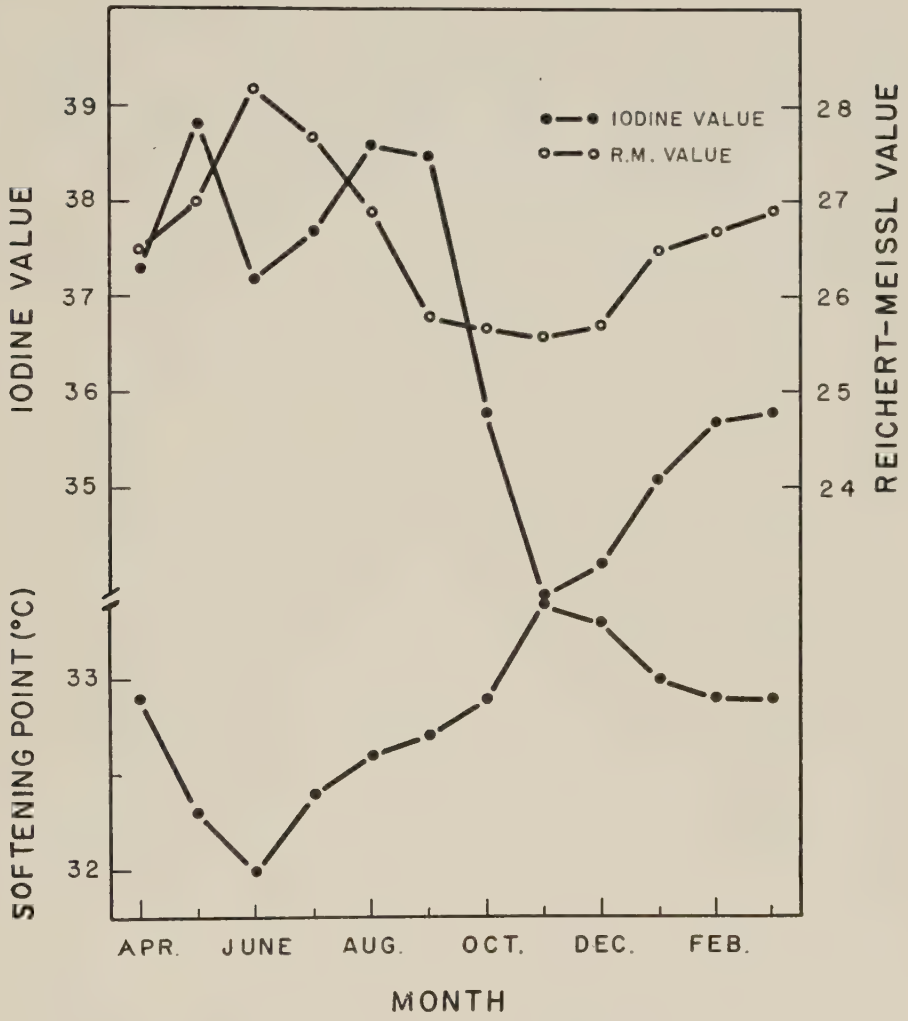

FIGURE 2. Softening points and iodine and Reichert-Meissl values for all sampling points.

were significant. The correlation coefficients of the data for Edmonton and Lethbridge butterfats, illustrated by curves in Figure 1, were found to be as follows:

Edmonton — r(softening points and iodine values) = −0.72
Edmonton — r(softening points and Reichert-Meissl values) = −0.83
Lethbridge — r(softening points and iodine values) = −0.87
Lethbridge — r(softening points and Reichert-Meissl values) = −0.73

DISCUSSION

The fact that the fluctuations noted during 1952-53 were closely duplicated in the second year's observations is consistent with New Zealand findings (3, 4). The statistically significant difference between the 2 years'

results for the softening points of Alberta butterfats appears to be caused mainly by the lower minimum values in June together with the recessions found in the month of September for all sampling points, other than Lethbridge, in 1953. The regional differences in the properties of these butterfats are comparable to those reported for the butterfats of the north and south islands of New Zealand by Cox and McDowall, where the dissimilarities are attributed largely to differing feeding practices. It may be that the properties of the Lethbridge butterfat are a reflection of the unusual feeding practices of that area, such as the use of beet-tops and other beet by-products known to influence iodine and Reichert-Meissl values.

The similarity in the average iodine values for Bonnyville and Red Deer, located in two distinctly different regions, appears to be inconsistent. There is no available information showing whether this similarity is reflected by similar body and spreading characteristics of the butter from these two sampling points. However, a similarity in average iodine values does not necessarily mean that the corresponding butters would be similar in body characteristics, as the seasonal fluctuation in iodine values could be quite different. Indeed, Table 1 reveals such differing seasonal fluctuations.

The August-September maximum, or near maximum, iodine values and refractive indexes for Bonnyville and Edmonton were unexpected, because pastures deteriorate rapidly at this season. High early fall iodine values and refractive indexes have, however, been reported recently in Canada* and elsewhere (7, 10). These observations support those of Smith and Dastur (9) and Mayhead and Barnicoat (5) on inanition effects.

Riel (8) in a survey of the fat constants of Canadian butterfat reported that Alberta butterfat, over a period of 12 months, showed a Reichert-Meissl value range of 25.1 – 29.5 and a range of 1.45386 – 1.45525 in refractive index. The corresponding ranges in the present study were very similar, being 24.1 – 29.5 and 1.45335 –1.45572. The refractive index variations are not dissimilar to those reported for New Zealand butterfat (6).

Figures 1 and 2 illustrate the close inverse relation between softening points and iodine values, and between softening points and Reichert-Meissl values, particularly for the Edmonton butterfat. The lack of correlation between late summer iodine values and softening points was unexpected but the inverse relation for the remainder of the year was close. The lower correlation between softening points and Reichert-Meissl values for Lethbridge butterfat than that found for Edmonton butterfat is caused in part, at least, by the inverse relation that exists between iodine and Reichert-Meissl values from September to December (Figure 1).

Alberta butterfat, because of its maximum iodine and Reichert-Meissl values in the summer season, more closely resembles European butterfat than that of New Zealand, where the seasonal trend of iodine values tends to be reversed. This may account for the lack of correlation between softening points and iodine and Reichert-Meissl values in the latter country (3, 4).

* Correspondence, Department of Dairy Science, University of Manitoba, Winnipeg, Man.

Cox and McDowall stress the empirical nature of these measurements and state that a close interpretation of the interrelation between the composition of the butterfat and softening points would have to await a detailed study of the fatty acid composition of butterfat. In their extensive study of the chemical composition of New Zealand butterfat by the ester-fractionation procedure, Hansen and Shorland (4) indicate that softening points appear to be influenced more by the lower saturated acids (C_4-C_{12}) than by the unsaturated acids. According to these investigators the lack of correlation in New Zealand between softening points and the content of acids liquid at room temperature suggests that softening points are dependent on the mode of the fatty acid distribution throughout the glyceride molecules.

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OCCURRENCE OF A DDT-RESISTANT STRAIN OF THE CABBAGE LOOPER, *TRICHOPLUSIA NI* (HBN.), IN THE OTTAWA VALLEY[1]

D. G. HARCOURT[2]

Vegetable Insect Section, Entomology Laboratory, Ottawa

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ABSTRACT

Reports by growers of the failure of DDT to control caterpillars (the imported cabbageworm, the diamondback moth, and the cabbage looper) on cabbage and cauliflower in the Ottawa Valley in 1955 were substantiated by experiments that showed that DDT was considerably less effective in preventing caterpillar damage in 1955 than in any other year since it was first tested at Ottawa in 1947. Field and laboratory data showed that an outbreak of a strain of the cabbage looper resistant to DDT was responsible for its lack of effectiveness, this caterpillar being four times more abundant than usual.

INTRODUCTION

During August and early September, 1955, several growers in the Ottawa Valley reported that DDT was ineffective against caterpillars on cabbage and cauliflower. By mid-September one grower had applied DDT ten times to his late cabbage without gaining appreciable control. Another grower had applied DDT at twice the recommended strength without success; several others had abandoned control measures.

In eastern Ontario, late plantings of cabbage and cauliflower are attacked every year by caterpillars of three species, namely, the imported cabbageworm, *Pieris rapae* (L.), the diamondback moth, *Plutella maculipennis* (Curt.), and the cabbage looper, *Trichoplusia ni* (Hbn.). The imported cabbageworm is the most important of the three species and causes damage of considerable economic importance each year. The diamondback moth, although much more numerous than the imported cabbageworm, is usually less important because of its smaller foliage consumption per larva (2). The cabbage looper is not sufficiently abundant in most years to constitute a commercial problem.

Because of the excellent control afforded by DDT and other chlorinated hydrocarbons, these insects have been given little attention by entomologists on this continent in recent years. However, in 1951, a strain of the imported cabbageworm resistant to DDT, TDE, and methoxychlor was found in Wisconsin (7). In 1953, a strain of the cabbage looper resistant to DDT was found in New York (4). Evidence of resistance to DDT by strains of one or both species has since been observed in Illinois and Connecticut (1, 8).

Experiments at Ottawa from 1947 to 1950 showed that almost complete control of caterpillars attacking late cabbage could be obtained with four properly timed applications of DDT (6). Experiments in 1953 and 1954 did not suggest any decline in its effectiveness (3). This is a report on further studies in 1955. These afforded an opportunity to determine whether the reports of resistance were well founded.

[1]Contribution No. 3434, Entomology Division, Science Service, Department of Agriculture, Ottawa, Canada.

[2]Associate Entomologist.

EXPERIMENTS AND RECORDS, 1947-1955

The DDT used in all experiments was a 3 per cent dust (prepared from DDT of 88° C. minimum setting point†, containing approximately 75 per cent *p-p*^{1}-isomer). It was applied with rotary hand dusters at 1 pound of toxicant per acre. Four applications were made in all experiments: on about July 20, August 3 and 17, and September 1. The schedule of application was held as constant from year to year as weather conditions would permit. The plots, which averaged one-fiftieth of an acre in size, were in growers' fields within 10 miles of Ottawa (Table 1). They were arranged in randomized blocks with 4 to 6 replications. Effectiveness of the material was based on feeding injury to the foliage shortly before harvest (3, 6).

Table 1 shows that, whereas DDT gave 96 to 100 per cent control of caterpillars on late cabbage from 1947 to 1954, it gave only 59 per cent control in 1955.

In 1955, counts of larvae were made on the treated and the untreated plants 1 week after each application. Twenty-five plants in each category were examined on each date: 6 plants at random from each of the 4 replicates, and 1 plant at random from one of the 4 replicates. Table 2 shows that DDT gave excellent control of the imported cabbageworm and the diamondback moth. Control of the cabbage looper was unsatisfactory.

† Green Cross Insecticides, Montreal 22, Que.

TABLE 1.—CONTROL OF CATERPILLARS ON PENN STATE BALLHEAD CABBAGE IN THE OTTAWA VALLEY WITH 4 APPLICATIONS* OF 3 PER CENT DDT DUST, 1947-50, 1953-55

Year	Locality	Cabbage plants		Percentage control
		Number examined	Percentage Grade 2**	
1947	City View, Ont.	520	0.0	100.0
1948	City View, Ont.	932	3.1	96.6
1949	Aylmer East, Que.	992	3.5	96.1
1950	City View, Ont.	513	0.0	100.0
1953	Aylmer East, Que.	666	0.8	99.2
1953	Merivale, Ont.	306	2.0	97.9
1954	Aylmer East, Que.	584	1.5	98.4
1955	Merivale, Ont.	354	40.7	59.3
Difference required for significance at 5% level			4.4	
	at 1% level		7.3	

* On about July 20, August 3 and 17, and September 1.
** Five or more leaves skeletonized (one-sixth or more of the surface of each leaf removed by feeding)

TABLE 2.—NUMBERS OF CATERPILLARS ON 25 TREATED AND 25 UNTREATED PLANTS OF LATE CABBAGE ONE WEEK AFTER EACH APPLICATION OF DDT, MERIVALE, ONTARIO, 1955

Species	July 25—26		August 8—9		August 25—26		September 6—7		Total		Percentage reduction
	DDT	Check	DDT	Check	DDT	Check	DDT	Check	DDT	Check	
Imported cabbageworm	11	147	66	869	2	7	0	6	79	1029	92.3
Diamondback moth	3	239	9	494	0	1015	10	894	22	2642	99.2
Cabbage looper	12	22	34	28	108	112	56	80	210	242	13.2

TABLE 3.—AVERAGE NUMBERS* OF LEPIDOPTEROUS LARVAE PER PLANT OF UNTREATED LATE CABBAGE IN THE OTTAWA VALLEY, 1948, 1950-1955

Year	Imported cabbageworm	Diamondback moth	Cabbage looper	Total
1948	7.6	5.7	0.3	13.6
1950	3.2	3.0	0.2	6.4
1951	7.8	11.1	0.1	19.0
1952	7.9	8.8	0.5	17.2
1953	4.5	19.8	0.8	25.1
1954	3.8	26.4	0.3	30.5
1955	5.7	19.5	1.6	26.8
Mean	5.8	12.5	0.4	18.7

* On the basis of weekly examinations, June to October. On the average, 800 plants were examined each year.

Table 3 shows the numbers of caterpillars recorded from untreated quarter-acre fields of late cabbage near Ottawa during seven of the past 8 years. The cabbage looper, which rarely forms a significant portion of the complex of lepidopterous species attacking cabbage in the Ottawa Valley, was unusually abundant in 1955. Its average numbers in 1955 were four times the recorded average for the previous 6 years and twice the recorded peak during those 6 years. Populations of the diamondback moth, although well above normal, were no higher than in 1953 and 1954. Numbers of the imported cabbageworm were average.

To determine whether a similar degree of tolerance to DDT by the cabbage looper occurred elsewhere near Ottawa, the following laboratory experiment was conducted in October, 1955. On October 12, several specimens of each instar, a total of 125 larvae in all, were collected at random from fields near Aylmer East, Quebec. Each was placed in a 115-mm. stacking dish containing a freshly cut, 3-inch disk of cabbage leaf. The leaf disks were obtained from a small field of Penn State Ballhead cabbage that had been dusted on the same day with 3 per cent DDT at 33 pounds per acre of the diluted dust. These were held at room temperature. Counts of the larvae at 72 hours showed that only 24.8 per cent mortality was effected by the DDT†. Surviving individuals fed normally, and, when provided with fresh, untreated foliage, completed their development, pupating within the dishes.

Interviews with growers during the fall of 1955 indicated that the failure of DDT was in no way attributable to neglect by the growers or to lack of adequate insecticidal coverage due to faulty equipment, poor timing, or improper concentration of insecticides.

† In 1944 similar tests with DDT by Huckett resulted in a mortality of 100 per cent at 48 hours (5).

CONCLUSION

An outbreak of a strain of the cabbage looper resistant to DDT was responsible for the insecticide's failure to give satisfactory control of caterpillars on cabbage in the Ottawa valley in 1955.

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EVALUATION OF CARCASS QUALITY IN SWINE AS INFLUENCED BY THE DIFFERENTIAL PERFORMANCE OF BARROWS AND GILTS[1]

H. T. Fredeen[2] and D. B. Lambroughton[3]

Canada Department of Agriculture

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ABSTRACT

A study involving 692 Yorkshire litter groups of 2 barrows and 2 gilts each, tested under the Canadian Record of Performance for Pure Bred Swine, substantiated previous findings of important sex differences in carcass quality. The magnitude of the sex differences in carcass measurements was relatively constant at all levels of litter performance. However, with carcass measurements converted to scores, the sex difference in total carcass score was related inversely to the average carcass score for the litter. This was shown to result from the carcass scoring system which rewards optimum rather than maximum carcass measurements and employs the same scoring standards for both sexes even though carcasses from gilts are superior in length and leanness to those from barrows. For breed improvement or for genetic studies it would appear desirable either to rely entirely on the actual measurements or to adopt a scoring system which accurately reflects the full range of carcass variation found in both sexes.

INTRODUCTION

Sex differences for carcass characteristics in the Canadian Yorkshire have been discussed by Bennett and Coles (1), Crampton (3) and Fredeen (4). All agree that females are longer and leaner than barrows and, therefore, obtain 6 to 8 per cent higher carcass scores in the Canadian Record of Performance tests for pure bred swine.

The existence of these sex differences is important in interpretation of results from nutritional experiments, litter tests concerned with breeding research, or litter tests related to a standard performance test. If such results are to be readily analysed equal sex representation must be provided within each experimental lot. Failing this, some method of statistical control must be employed in analysis. Usually this control amounts to adjustment of litter means for any disproportionate sex representation that exists.

This problem has long been recognized in Denmark where considerable emphasis is placed upon equal sex representation in test litters. However, Danish workers have computed correction factors, applied directly to the carcass measurements (2) to adjust for disproportionate sex representation. In Canada, the official performance test provides a total carcass score that is the sum of the individual scores assigned to the several objective carcass measurements. At present, no correction is made for sex imbalance in the test litters.

The purpose of this present investigation was to re-appraise the differences between barrows and gilts, both in carcass measurements and in scores, and to explore possible means of adjustment for these differences.

[1] Contribution from the Animal Husbandry Division, Experimental Farms Service, and the Livestock and Poultry Division, Production Service, Canada Department of Agriculture.
[2] Geneticist, Experimental Farm, Lacombe, Alberta.
[3] Technical Officer, Production Service, Ottawa, Ontario.

TABLE 1.—AVERAGE CARCASS MEASUREMENTS AND SCORES FOR LITTER MATE BARROWS AND GILTS RANKED ACCORDING TO MEAN CARCASS SCORE FOR THE LITTER.

	Average carcass score of litters	N	CARCASS MEASUREMENTS						CARCASS SCORES					
			Car. wt. (lb.)	Length (in.)	Sh. fat (in.)	Back fat (in.)	Loin fat (in.)	Loin area (sq. in.)	Length	Back fat	* Bal.	Belly	Loin	** Total
GILTS	to 45	4	152.2	30.38	1.98	1.25	1.68	3.42	10.2	2.8	7.2	8.5	12.5	51.2
	45—49	6	149.5	29.74	1.95	1.02	1.55	3.38	6.7	6.8	8.0	14.7	11.3	57.5
	50—54	16	149.6	30.51	1.94	1.08	1.52	3.34	13.6	8.3	6.5	13.0	12.0	63.4
	55—59	40	150.2	30.36	1.96	1.08	1.55	3.74	12.2	5.8	7.2	15.3	15.6	66.1
	60—64	102	151.4	30.50	1.87	.97	1.44	3.62	13.9	9.7	7.1	16.2	14.2	71.1
	65—69	174	149.7	30.59	1.83	.96	1.43	3.84	14.6	10.4	7.1	16.4	16.7	75.2
	70—74	292	149.8	30.92	1.79	.90	1.34	3.89	17.2	11.7	6.7	16.5	17.2	79.5
	75—79	334	150.3	31.06	1.74	.87	1.31	4.04	17.5	13.1	6.9	17.1	18.2	82.8
	80—84	246	150.4	31.27	1.69	.85	1.25	4.08	18.4	14.7	6.8	17.3	18.6	86.0
	85—89	138	149.3	31.44	1.65	.84	1.23	4.17	19.1	16.1	7.0	18.0	19.2	89.6
	90 +	32	150.5	31.52	1.65	.86	1.25	4.27	18.9	17.7	7.7	19.1	19.8	93.2
	Total N	1384												
	Average			30.98	1.76	.90	1.33	3.96	16.9	12.6	7.0	16.8	17.5	80.8
	Standard Deviation			.754	.193	.162	.186	.486	4.25	5.22	—	3.38	3.36	10.68
	Coeff. of Variation (%)			2.6	11.0	18.0	14.0	12.3	25.1	41.4	—	20.1	19.2	12.7

BARROWS	to 45	4	151.5	29.75	2.15	1.32	1.85	2.82	8.0	.5	5.8	4.0	4.5	32.8
	45—49	6	149.0	29.80	2.05	1.18	1.78	3.06	7.3	.3	7.7	5.7	7.0	38.0
	50—54	16	149.2	29.83	2.11	1.28	1.78	2.92	8.8	1.6	6.5	9.1	6.6	42.6
	55—59	40	150.9	29.96	2.07	1.21	1.68	3.20	9.0	3.1	6.0	11.4	9.5	49.0
	60—64	102	150.6	30.18	2.04	1.13	1.63	3.12	11.4	2.9	6.7	12.9	8.5	52.4
	65—69	174	150.4	30.39	1.98	1.12	1.60	3.28	12.9	4.8	6.7	14.3	10.6	59.5
	70—74	292	150.3	30.60	1.92	1.08	1.53	3.34	14.8	6.9	6.6	14.8	11.5	64.6
	75—79	334	150.5	30.80	1.88	1.02	1.46	3.43	16.1	9.6	6.5	16.0	12.8	71.0
	80—84	246	150.8	30.98	1.81	.97	1.36	3.57	17.1	12.9	6.7	16.6	14.4	77.7
	85—89	138	148.9	31.22	1.74	.93	1.33	3.69	18.4	14.5	7.0	17.4	16.0	83.1
	90 +	32	150.0	31.38	1.73	.89	1.28	3.88	19.4	16.5	7.3	17.6	17.4	88.4
	Total N	1384												
	Average			30.71	1.89	1.04	1.48	3.42	15.2	8.8	6.7	15.3	12.4	68.4
	Standard Deviation			.657	.195	.171	.201	.455	5.22	6.54	—	4.25	5.17	13.96
	Coeff. of Variation %			2.1	10.3	16.4	13.6	13.3	34.3	74.3	—	27.8	41.7	19.5

* The score for balance, based on the relative proportions of ham, middle, and shoulder, was not considered of sufficient importance to merit discussion. It has been included here merely to indicate its contribution to total score.

** Total scores all include 10 points for "type", a factor not itemized in the body of the table.

MATERIALS AND METHOD

Carcass data were obtained for 692 purebred Yorkshire litters, of 2 barrows and 2 gilts, which completed official test on the Canadian Record of Performance for pure bred swine during the year 1952, 1953, and 1954. Feeding and management practices employed for the test were held constant during this period. Two changes in scoring were adopted in 1954. One provided a minor adjustment in the scoring for backfat and the other specified warm rather than cold carcass weight as the basis for determining the weight range for scoring. These regulations are detailed in a publication from the Federal Department of Agriculture*.

One of the scores assigned in the Record of Performance test applies to a completely subjective measure of "type". Only two scores may be obtained for type, either 10 or zero. For purposes of this study, which was primarily concerned only with objective measurements and their scores, such a factor could introduce anomalous results. To avoid this difficulty all total carcass scores were examined and 10 points were added to scores where the type rating was zero. This adjustment was required for 77 barrows and 33 gilts.

Following this correction, all litters were ranked according to their adjusted mean carcass score and grouped at intervals of 5 points. Within each group the gilt means for all carcass measurements and scores were compared with those obtained by their contemporary litter-mate barrows.

RESULTS

Average carcass measurements and scores for individual carcass traits are presented in Table 1. These data provide a comparison of the differences that exist between litter-mate barrows and gilts in each of the average litter-score sub-groups.

The arrangement of these data has resulted in each carcass score sub-group being superior to the preceding sub-groups in all important carcass measurements and scores. This merely reflects the fact that an increase in mean carcass score of the litter is generally dependent upon greater length, less back fat, greater loin area, and improved belly quality of the tested litter mates and that at any given level of carcass quality no one factor is exerting undue influence.

Table 1 illustrates that gilts were consistently superior to their litter mate barrows in all carcass measurements and scores. The sex differences in carcass measurements do not appear to be related to the average carcass score of the litter. However, in the scores assigned to individual traits, the gilts start at a higher level and increase at a slower rate than do the barrows. Associated with this is the fact that variation in carcass measurements, as measured by either the standard deviation or the coefficient of variation, is similar in the two sexes, whereas in carcass scores for these individual traits the gilts show appreciably less variation than the barrows (Table 1).

That these sub-group differences are free from any bias which might be introduced by carcass weight is indicated by the close similarity that exists in average carcass weight both within sexes and between comparable sex sub-groups (Table 1).

* National Bacon Hog Policy. Record of Performance and Advanced Registry for Purebred Swine. Production Service, Department of Agriculture, Ottawa. October, 1954.

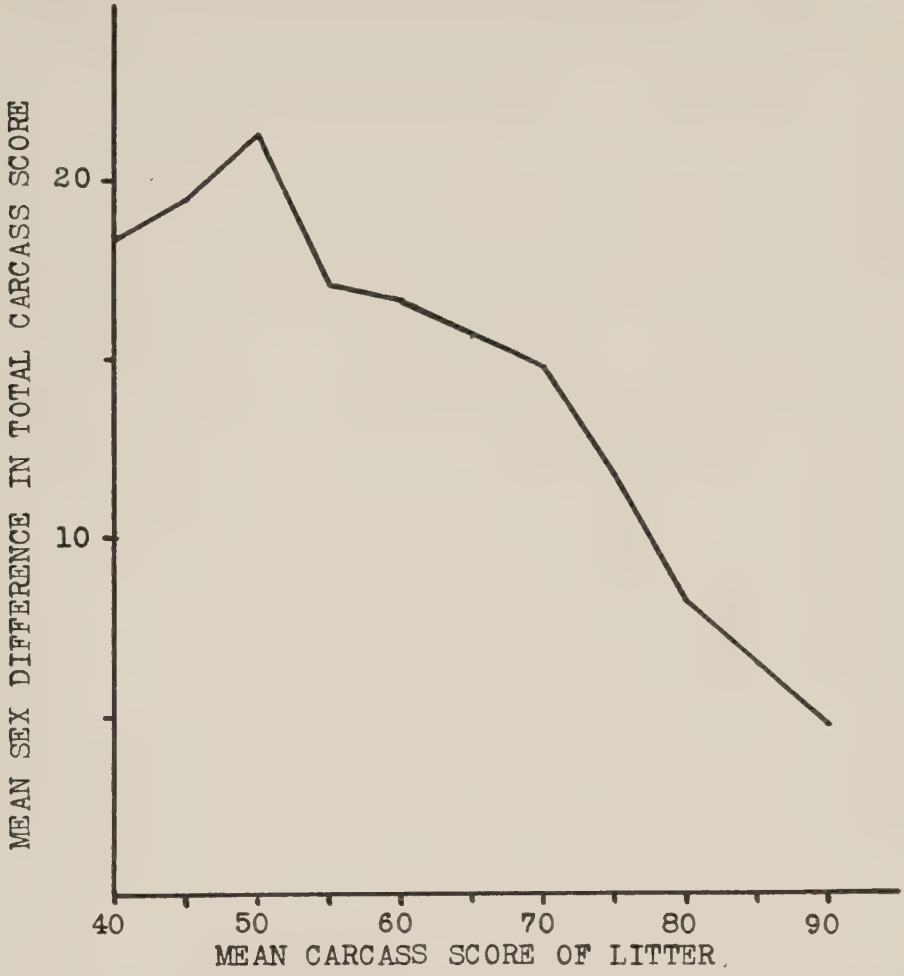

FIGURE 1. Mean differences in total carcass score between litter-mate barrows and gilts, shown in relation to the mean carcass score of the litter.

The net result of these differences in scores for the individual traits is shown by comparison of the total carcass scores for the barrows and gilts of contemporary sub-groups. Although the mean sex difference was 12.4 points in favour of the gilts the actual sex difference in total score appears to be related to the level of carcass performance of the litter, being gradually but steadily reduced as total litter score increases. This is illustrated clearly by Figure 1, which relates the mean sex difference in total carcass score to the mean carcass score of the litter. From this figure it is apparent that the sex difference in total carcass score fell from a maximum of about 21 points to a minimum of approximately 5 points as the average litter score increased from 50 to 90.

This inverse relationship between the magnitude of the sex difference in total score and the average carcass score of the litter is shown by the data of Table 2 to be characteristic of each of the 7 stations and each of the 3 years involved in the study.

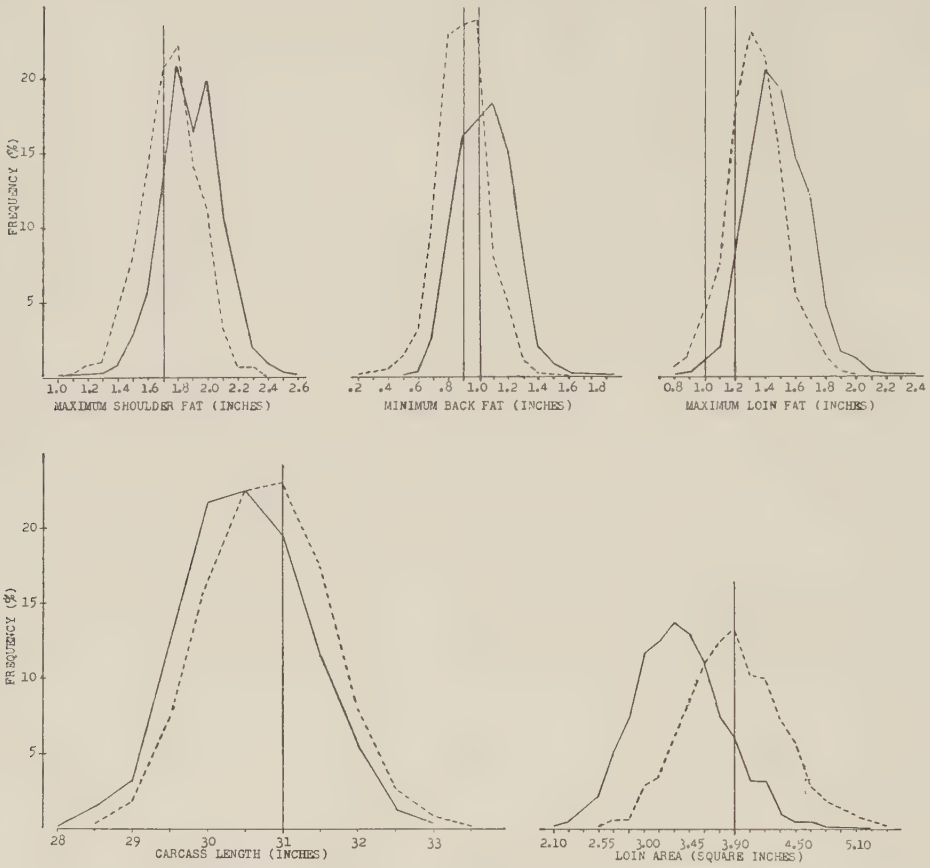

FIGURE 2. Frequency distribution for the 2 sexes in shoulder fat, back fat, loin fat, carcass length, and loin area. (Cross section of longissimus dorsi). Males ——— Females – – – –.

In explanation of this result the data of Figure 2 are of considerable interest. This figure depicts the frequency distributions of the 1384 pigs of each sex in shoulder fat, back fat, loin fat, carcass length, and loin area (cross-section of the longissimus dorsi). Lines drawn vertically through these curves mark the levels of performance required by the Record of Performance standards for attainment of maximum score in each characteristic. These levels are based on an average carcass weight of 150-159 lb.

Within this weight range, individuals measuring 31.0 or more inches in length or 3.90 or more square inches in loin area are assigned the maximum of 20 points for each trait. The maximum of 20 points for "back fat" is assigned to individuals possessing 1.7 inches or less in maximum shoulder fat, 0.9 to 1.0 inches in minimum back fat, and 1.0 to 1.2 inches in maximum loin fat.*

* Carcass measurements show an almost linear response to differences in carcass weight (4). Heavier carcasses are longer with greater loin area and an increased depth of all fat measurements. In recognition of this fact the Record of Performance standards provide for scoring within three carcass weight ranges: 140-149 lb., 150-159 lb., and 160-169 lb. The measurements required for equal score at these weights differ by 0.5 in. in carcass length, 0.1 in. in maximum and/or minimum fat measurements and 0.20 square in. in loin area.

TABLE 2.—AVERAGE SEX DIFFERENCE (F-M) IN TOTAL CARCASS SCORE ARRANGED ACCORDING TO AVERAGE CARCASS SCORE OF THE LITTER AND YEAR AND PROVINCE (TEST STATION) OF ORIGIN. THE FIGURES IN BRACKETS INDICATE THE NUMBER OF PIGS CONTRIBUTING TO THAT SPECIFIC AVERAGE.

Province	Average Carcass Score of the Litter				
	to 54	55—64	65—74	75—84	85+
Prince Edward Island		13.5 (6)	20.7 (42)	13.5 (112)	8.3 (74)
Nova Scotia and New Brunswick		8.5 (6)	15.3 (26)	8.7 (44)	
Quebec	16.7 (10)	9.3 (36)	14.4 (88)	9.2 (50)	2.2 (4)
Ontario	24.0 (8)	20.6 (28)	13.6 (154)	9.2 (192)	2.1 (30)
Manitoba	24.2 (4)	23.2 (14)	13.2 (46)	9.9 (62)	3.6 (14)
Saskatchewan		16.8 (16)	13.3 (54)	7.4 (62)	5.9 (36)
Alberta	22.0 (4)	26.8 (36)	22.0 (56)	13.5 (58)	7.6 (12)
1952	16.4 (6)	18.9 (68)	13.1 (190)	9.6 (192)	6.0 (64)
1953	18.5 (8)	18.3 (38)	17.8 (180)	11.3 (186)	6.9 (60)
1954	33.1 (12)	17.2 (36)	14.6 (96)	10.1 (202)	5.4 (46)

It is clear that the levels for maximum score impose limits beyond which a more extreme expression of the carcass trait being considered will not be rewarded by an increased score. Since both sexes are scored according to the same performance scale, the sex with average performance nearest this arbitrary limit will have the lesser opportunity to express, through its total carcass score, the true variability exhibited in its various carcass measurements.

In loin area, for example, the range of variability in the gilts was from 2.55 to 5.55 square inches with an average of 3.96. For the barrows the range was 2.11 to 5.29 with an average of 3.42. The maximum score of 20 points is obtained by all individuals with a loin area of 3.90 or over—slightly less than the gilt average. Thus 59 per cent of the gilts but only 16 per cent of the barrows obtained this maximum score.

The same pattern holds true of the other carcass measurements. Gilts were longer than barrows; consequently 56 per cent of the gilts as contrasted with 40 per cent of the barrows obtained maximum points for length. Gilts were also thinner in back fat; however, in this trait the ideal carcass is considered to be intermediate, and 39 per cent of the gilts but only 12 per cent of the barrows lost points through having less than the optimum depth of back fat. In belly quality, where the ideal is a bacon rasher combining optimum proportions of fat and lean, approximately 40 per cent of the gilts and 19 per cent of the barrows were assigned the maximum score. Again, the number of bellies scored downwards though a tendency towards thinness was considerably greater among the gilts than among the barrows.

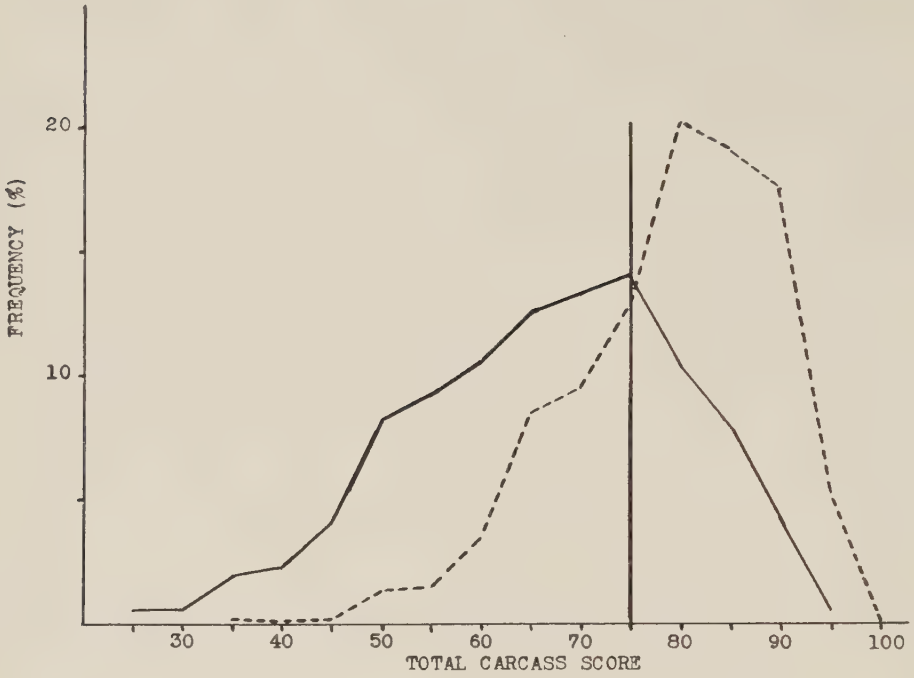

FIGURE 3. Frequency distribution of barrows and gilts in total carcass score.

The fact that an intermediate optimum is favoured in back fat thickness confuses the interpretation of scores for this trait. A score of 6 points may mean that the carcass was too thin with less than 0.6 inches of back fat; conversely, the same score will be applied to all carcasses with back fat in excess of 1.3 inches. Obviously, the meaning of the score will not be clear unless the actual measurements are examined. Scores for belly quality present a comparable problem, and the joint contribution of these two factors to total carcass score may lead to the anomalous situation where the gilts will actually receive lower total scores than their shorter, fatter litter-mate barrows. This situation has to be considered in any study utilizing total carcass score.

The cumulative effect of this scoring system is illustrated by Figure 3 which depicts the frequency distribution of the two sexes in total carcass score. Three-quarters of the gilts, and slightly more than one third of the barrows tested, obtained 75 or more points in total score. Both distributions are skewed, a condition imposed by inability of the scoring system to express the full range of variation found in the actual carcass measurements. The skewness is more extreme in the case of the gilts because their average carcass measurements are nearer the arbitrary limits required for maximum scores under the single set of scoring standards.

DISCUSSION

In considering any one carcass measurement gilts are expected to be superior to their litter-mate barrows. The data of Table 1 indicate the

magnitude of this superiority to be relatively constant at all levels of litter performance in carcass quality. However, this is not true of the scores assigned to individual carcass traits in the Canadian Record of Performance test. In these the magnitude of the sex difference shows a gradual reduction as the average performance of the litter improves.

This inverse relationship arises from the application of a scoring system which rewards optimum rather than maximum carcass measurements and which employs the same scoring standards for both sexes. Thus, when gilts within the warm carcass weight range of 150-159 lb. measure 3.90 square inches in loin area they will receive the maximum of 20 points for this trait. Further improvement in loin area will not be reflected in an increased score yet the loin area of gilts must increase, on the average, to approximately 4.44 square inches before their litter mate barrows will attain the loin area of 3.90 square inches which qualifies them for the maximum loin score of 20 points. A similar situation exists as regards the score for carcass length while, conversely, in back fat and belly quality the gilts can become too thin with a resultant reduction in score while the corresponding scores for their litter mate barrows are still increasing.

Because of these relationships it is clear that adjustments applied directly to total carcass score would be inadequate to correct for sex differences in carcass quality. Furthermore, even among litters balanced for sex, a true measure of the actual differences in carcass measurements cannot always be obtained by examination of the carcass scores.

One remedy for this situation could be the adoption of a dual set of scoring standards, one for barrows and one for gilts, which would take into account the actual sex differences in carcass measurements. The data of Table 1 suggest that these differences are greater than those reported by Fredeen (4) for the period 1939-1949. Ration and feeding method changes introduced in the test procedure in 1952 may account for the contrasting results of the two periods. However, the differences reported in this study should be verified by a complete analysis before being used in the establishment of dual scoring standards.

One additional feature of the present scoring system deserves consideration. The basic purpose of the Record of Performance test is to provide information that may aid in the general improvement of swine. In this test, the ideal carcass is considered to be one that is "optimum" in all traits, in other words, a carcass that is intermediate to the extremes. In assigning maximum scores to "intermediate" pigs the Record of Performance test, in effect, advocates that intermediate pigs are the most desirable from the standpoint of effecting genetic improvement. The genetic soundness of this implication is open to question. Moreover, little research work has been done in Canada to establish the standards which would determine a carcass of optimum utility.

If scoring of carcass quality is desirable, and if the scores are to be of value in the selection of breeding stock, the scores assigned should be capable of reflecting the entire range of variability exhibited by the tested population. Each increment added to length or to loin area, or taken away from the thickness of back fat, should provide an additional increment to the carcass score. The "optimum" carcass might still obtain

a carcass score of 100, but scores in excess of this figure would indicate carcasses that were longer or leaner than considered optimum. This information could be of definite practical value in a selection program.

Were such a system adopted, the need for separate scoring standards for each sex no longer would be imperative. Under the present scoring standards, corrections for sex differences in carcass scores are inadvisable primarily because these standards favour the intermediate type of carcass. Removal of the score "ceilings" thus imposed would eliminate this objection.

A total score which expresses the entire range of variability exhibited by the tested population would be of advantage in the practical application of test results. However, from the experimental standpoint, particularly in terms of breed improvement or for genetic studies, it might be desirable to rely entirely on the actual carcass measurements. These, being free from any possible bias introduced by a scoring system, will always provide valid comparisons of group means, provided, of course, that any necessary statistical adjustments are made to compensate for differential sex representation between groups.

ACKNOWLEDGEMENT

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A TEN-YEAR STUDY OF THE CLIMATOLOGY OF *MELANOPLUS MEXICANUS MEXICANUS* (SAUSS.) (ORTHOPTERA: ACRIDIDAE) IN SASKATCHEWAN[1]

H. R. MacCarthy[2]

Field Crop Insect Section, Entomology Laboratory, Kamloops, B.C.

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ABSTRACT

High correlation coefficients between population indexes of adults of *Melanoplus mexicanus mexicanus* (Sauss.) in various areas of Saskatchewan in the years 1943 to 1952 and records of weather factors in the same areas up to 14 months earlier suggest causal relationships. The most critical months were June, August, and September of the previous year and June of the current year, the periods of hatching, nymphal development, oviposition, and hatching. July was the least important of the summer months. Temperature, especially daily minima, influenced later populations more than any other weather factor, during the previous June and August, and daily maxima during the previous August and the current June. Sunshine was important during August and especially September. Correlation with rainfall during the previous August and September was high and negative. Evaporation showed erratic correlation.

INTRODUCTION

Although serious invasions have occurred, the grasshopper problem in the Prairie Provinces of Canada is primarily one of resident populations of solitary grasshoppers producing a single generation annually. The most destructive and economically important of these is the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.). The area in Saskatchewan most often infested includes upwards of 40 million acres (Figure 1). Between 1943 and 1952 grasshopper numbers in southern Saskatchewan rose to very high levels, and then declined to the lowest point in 20 years. Standard data on populations of *M. m. mexicanus* were recorded during the period. This paper deals with these data and is another of many such attempts (8) to relate grasshopper populations and weather. Five large areas were chosen for the study, surrounding Prince Albert, North Battleford, Saskatoon, Moose Jaw, and Swift Current.

The physiography of the region is shown (Figure 2), with agricultural use of the land (Figure 3), and types of soils (Figure 4). In general, *M. m. mexicanus* maintains itself most readily on light, easily warmed soils.

The climate is typically north temperate continental, with very wide seasonal and diurnal temperature ranges and a low annual precipitation about half of which falls during June, July, and August (Figure 5). Summer rainfall is not usually over 2 inches per month, and stored soil moisture is often exhausted by July 1, after which plants must depend on current rainfall (12). Winter snowfall is normally light. The number of hours of sunshine is high, and prevailing winds are westerly.

[1]Contribution No. 3440, Entomology Division, Science Service, Department of Agriculture, Ottawa Canada.

[2]Associate Entomologist; now Officer-in-Charge, Entomology Laboratory, Vancouver, B.C.

FIGURE 1. Area in southern Saskatchewan subject to periodical outbreaks of *M. m. mexicanus* (Sauss.).

A soil zone-climatic index of moisture efficiency has been worked out by W. Millsap and reported by Mitchell *et al.* (7, Table 2, p. 20). By empirical methods based on long-term meteorological data for Swift Current, he calculated index numbers for points across the Province. Plotted on a map (Figure 6), they indicate the change from the low moisture efficiency of the semi-arid southwest to the higher efficiency of the subhumid north and northeast (12).

Largely because of the severe winters, the grasshopper problem on the Canadian prairies differs from that in most other areas, with the possible exceptions of Siberia, central Asia, northern Russia generally, and the northern United States. The most important contributing factor is probably the single annual generation, dictated by the short summer. The difference is partly due to the facts that breeding does not proceed undisturbed as in desert areas, and control measures are available at short notice. In none of the classic locust countries of the Old World, or in South America or Australia, have these conditions obtained in the past.

In general the problem has three characteristics: (a) There are no critical outbreak areas from which large numbers originate consistently. (b) The grasshoppers do not swarm at any stage; they may disperse with the aid of wind, occasionally invading from the south in large numbers, but never as coherent groups. (c) Economic, i.e., prolific, species are consistently associated with cultivated land.

FIGURE 2. Physical features of southern Saskatchewan. [From Mitchell *et al.* (7)].

MATERIALS

Weather records from the Meteorological Division, Canada Department of Transport, and population records from the annual grasshopper surveys of the Entomology Division were subjected to statistical analysis.

Each of the five study areas centred upon a Class I weather station of the Meteorological Division, and represented an area that differed slightly in topography and climate from the others. Each was infested in some degree during 8 or more of the 10 years. Since clear-cut natural boundaries are lacking in Saskatchewan, the area within 50 miles of each centre, or 7,854 square miles (Figure 7), was selected. Data from Class II weather stations within the study areas were also included in the analysis.

The Meteorological Division issues an 8-page sheet monthly, 3 to 6 weeks after the month reported, and about 2 years later a monthly record in considerable detail (1). Most of the data in this study came from the latter.

Figures for direct open-tank or free-surface evaporation were obtained from records taken at Swift Current and Scott, 33 miles southwest of North Battleford (10).

Maps recording the infestations for 1943-52 provided the population data. The maps show areas with adult *M. m. mexicanus* populations in five categories: one-half to one per square yard; one to two; two to four; four to eight, and more than eight.

FIGURE 3. Agricultural use of land in southern Saskatchewan. [From Mitchell *et al.* (7)].

The grasshopper populations in the Prairie Provinces are surveyed twice per year. In the late fall an egg survey is conducted as the basis of forecasts for the following year (5, 16). During August, an adult survey is made of all settled areas subject to infestation. Depending on the severity of the infestation, three or more surveyors take samples (15) every 5 to 7 miles, on routes 12 to 20 miles apart (Figure 8).

Samples are taken in all areas with economic infestations and also in country with populations consistently below the economic level, to try to determine trends. During a year of low populations, fewer samples are taken and less ground is covered than in an outbreak year. In the low grasshopper year of 1952, 776 samples were taken in Saskatchewan (Figure 8). In the high year of 1949 there were 1,567.

The mean number of population samples taken in the adult survey per year and the range during the 10 years in each of the five areas studied were as follows:—

	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current
Mean	39	99	176	150	148
Range	14–72	41–158	131–255	105–232	77–228

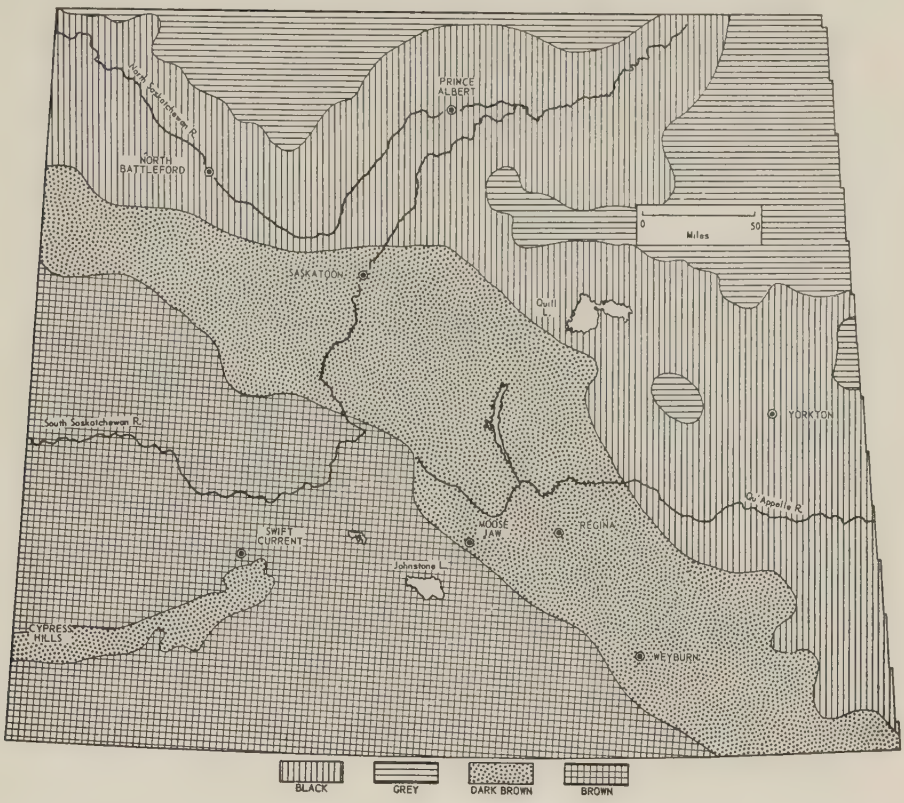

FIGURE 4. Major soil zones of southern Saskatchewan. [From Mitchell *et al.* (7)].

The number of observations on which the weather data were based varied from 30 for per cent possible sunshine, or 1 per day for a month at one station, up to 540 for mean daily temperature, or 2 per day for a month at each of nine stations in the Swift Current area.

METHODS

On the map for each year, the areas of infestation studied were measured with a planimeter and summed by categories; then the total area in each category was multiplied by the appropriate midpoint factor (0.75, 1.50, 3, 6, and 12, respectively). The products were summed and transformed by log $(x + 1)$ to give a population index in a given area and year.

Correlation coefficients (r) were calculated between populations of adult grasshoppers and eight weather factors on the assumption that the relationships were linear. For each area, the population indexes were correlated with the values for the weather factors for various months of the same and of the preceding year. Values of r within any one area cannot be independent of one another, because the population figures used were the same. In Tables 2–6, the r values read vertically are not independent; read horizontally they are independent and may be compared.

The Meyer ratio, precipitation/vapour pressure deficit, was calculated, for although empirical and open to criticism (17) it probably gives a better

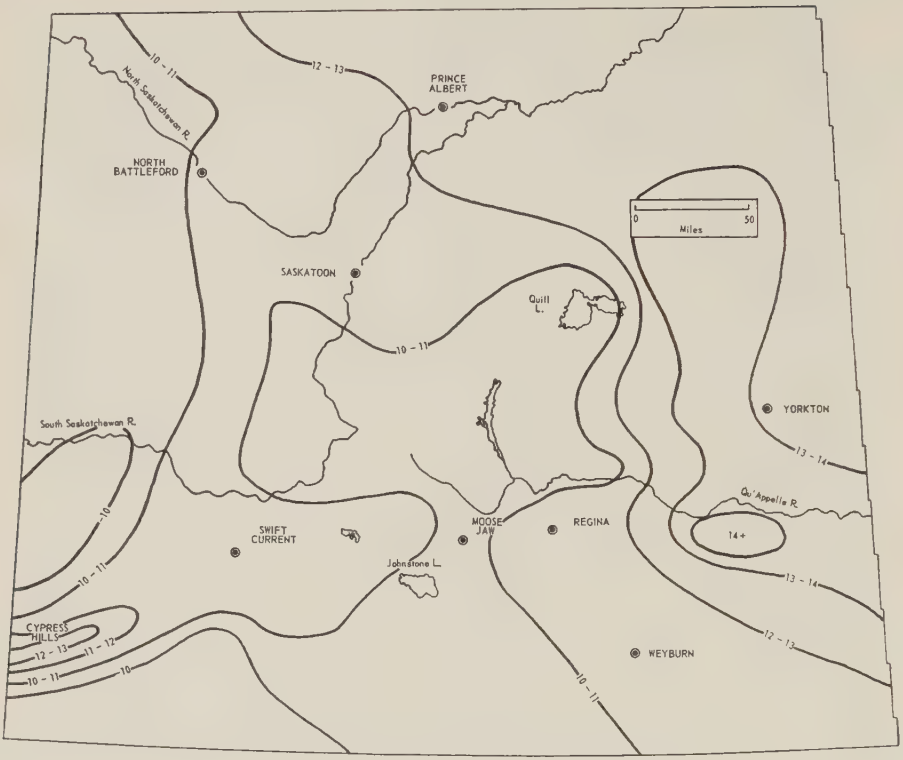

FIGURE 5. Average summer precipitati on in inches, April to October, in southern Saskatchewan. [From Champlin *et al.* (2)].

indication of evaporation than the open-tank system. Vapour pressure deficit was derived as follows: by means of a nomogram (4), Meteorological Division records of relative humidity and dry bulb temperature were read as vapour pressure, which was then subtracted from the appropriate saturation vapour pressure.

CORRELATIONS AND DISCUSSION

Exploratory study of figures for the Province as a whole suggested that the population in any one year was influenced considerably by weather factors of the summer and early fall months of the previous year. The averages of the data reported by the Class I stations at Swift Current,

TABLE 1.—CORRELATION COEFFICIENTS OF POPULATIONS OF *M. m. mexicanus* ADULTS IN THE PROVINCE OF SASKATCHEWAN WITH 3 WEATHER FACTORS AT SWIFT CURRENT, MOOSE JAW, AND REGINA, FOR 4 MONTHS OF PREVIOUS YEARS, 1943—1952.

Factor	Previous June	Previous July	Previous August	Previous September
Mean monthly temperature	.652*	.383	.704*	.501
Per cent possible sunshine	.029	−.347	.699*	.638*
Total precipitation	−.346	.173	−.420	−.610

* Significant at 5 per cent level.

TABLE 2.—CORRELATION COEFFICIENTS OF VARIOUS WEATHER FACTORS DURING JUNE WITH POPULATIONS OF *M. m. mexicanus* ADULTS THE FOLLOWING SEASON IN THE AREAS STUDIED.

Factor	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current	Pooled *r*	χ^2
Mean monthly temperature	.744*	.193	.615	.588	.632*	.555	2.204
Maximum monthly temperature	.612	.041	.366	.448	.468	.381	1.695
Minimum monthly temperature	.640*	.690*	.789*	.728*	.828**	.723*	0.792
Per cent possible sunshine	.001	−.132[1]	−.157	−.103	.496	−.065	2.413
Evaporation (Meyer ratio P/V. P.D.)	.171	.245	.202	−.283	−.435	−.027	3.038
Precipitation	.251	.281	.325	−.394	−.439	−.001	4.608
Vapour pressure deficit	.696	.120	.128	.008	.199	.209	3.232
Evaporation (open tank)		−.601[1]			.091		

* Significant at 5 per cent level.
** Significant at 1 per cent level.
[1]Sunshine and evaporation were not recorded at North Battleford but at Scott, 33 miles southwest.

TABLE 3.—CORRELATION COEFFICIENTS OF VARIOUS WEATHER FACTORS DURING JULY WITH POPULATIONS OF *M. m. mexicanus* ADULTS THE FOLLOWING SEASON IN THE AREAS STUDIED.

Factor	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current	Pooled r	χ^2
Mean monthly temperature	.483	.269	.317	.441	.290	.346	0.351
Maximum monthly temperature	.392	.293	.095	.389	.408	.304	0.555
Minimum monthly temperature	.511	.176	.526	.414	.403	.393	0.724
Per cent possible sunshine	.227	.067[1]	.176	−.204	−.196	.013	1.190
Evaporation (Meyer ratio P/V.P.D.)	−.239	.054	−.141	−.003	.178	−.005	0.771
Precipitation	−.246	−.376	−.154	.132	.284	−.070	2.195
Vapour pressure deficit	.421	.662*	.332	.469	.257	.429	1.085
Evaporation (open tank)		.080[1]			.024		

* Significant at 5 per cent level.
[1] Sunshine and evaporation were not recorded at North Battleford but at Scott, 33 miles southwest.

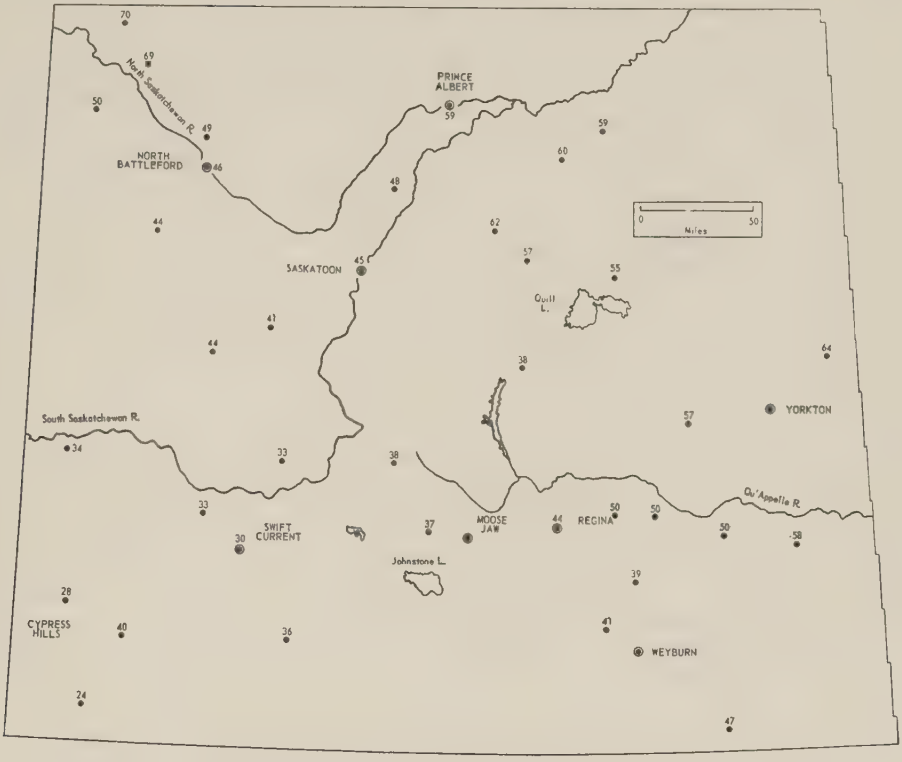

FIGURE 6. Indexes of moisture efficiency in southern Saskatchewan. [Based on Mitchell *et al.* (7, Table 2, p. 20.)]

Moose Jaw, and Regina for certain weather factors showed significant correlation with the population index for the Province. Some of these values of r are shown in Table 1.

Correlations for June to September of the previous year and June of the survey year are shown (Tables 2–6). In each of Tables 2–6 the correlation of population with mean monthly temperature probably represents the strongest relationship (8). Minimum temperatures in June appear to have a marked, uniform, positive influence on the population in the following year, most probably by their effect on the emerging and developing nymphs, higher than average minima permitting nymphs to mature and the adults to reproduce earlier. Minimum temperatures in September appear to have little effect on the subsequent population, probably because many eggs are already laid and the insects are uniformly mature. Maximum temperatures in August and September appear to exert considerable influence on the subsequent population in the south, and those occurring in June of the survey year appear to exert some influence towards the north. In Canada it is rare for drought to kill grasshoppers directly or to kill or inhibit vegetation to the extent that this becomes a limiting factor.

TABLE 4.—CORRELATION COEFFICIENTS OF VARIOUS WEATHER FACTORS DURING AUGUST WITH POPULATIONS OF *M. m. mexicanus* ADULTS THE FOLLOWING SEASON IN THE AREAS STUDIED.

Factor	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current	Pooled *r*	χ^2
Mean monthly temperature	.498	.610	.655*	.770**	.702*	.641*	1.058
Maximum monthly temperature	.360	.521	.654*	.775**	.721*	.605	1.917
Minimum monthly temperature	.509	.557	.563	.665*	.507	.542	0.268
Per cent possible sunshine	−.139	.579[1]	.450	.721*	.799**	.512	6.148
Evaporation (Meyer ratio P/V.P.D.)	.652*	.007	−.231	−.548	−.781**	−.233	13.108
Precipitation	.746*	.259	.057	−.381	−.797*	−.040	16.417*
Vapour pressure deficit	.196	.554	.580	.615	.506	.481	1.191
Evaporation (open tank)		.061[1]			.472		

* Significant at 5 per cent level.
** Significant at 1 per cent level.
[1] Sunshine and evaporation were not recorded at North Battleford but at Scott, 33 miles southwest.

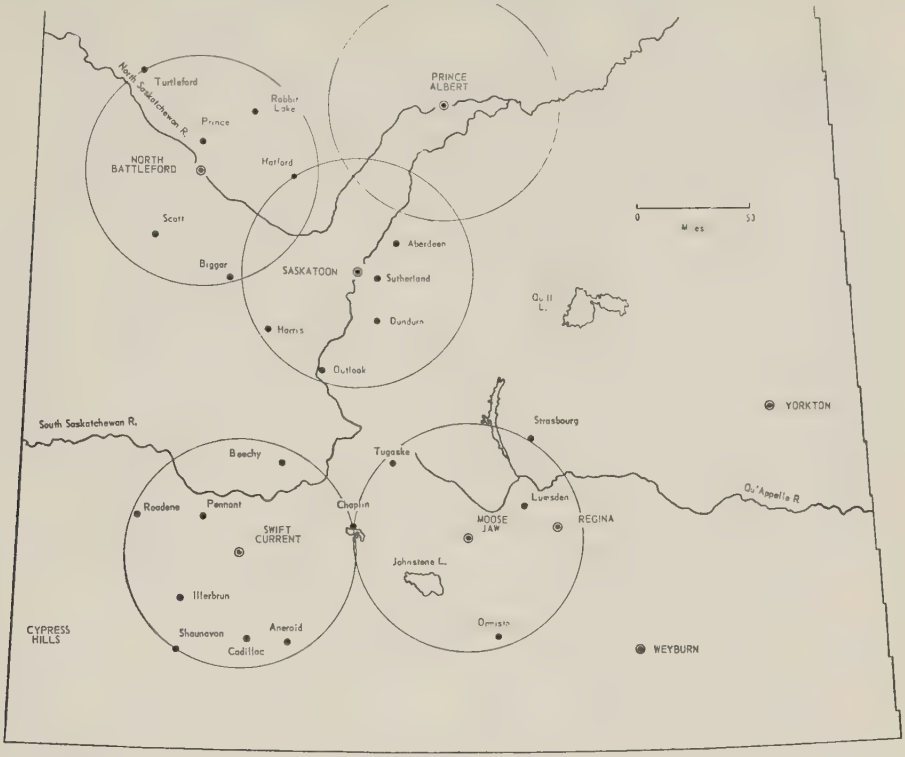

FIGURE 7. Class I and Class II weather stations in the areas studied in southern Saskatchewan.

Precipitation, within the limits of the prairie averages, appears to have less influence than temperature upon future populations of *M. m. mexicanus*, to judge by the consistently low pooled *r* values. This might be expected from the observation that ordinary rainfall is physically detrimental to grasshoppers only as young nymphs and at oviposition (3, 11). Tables 2–6 suggest that populations in northern and southern areas are affected differently by rainfall. Lack of homogeneity in the relationship is shown by the high values in the χ^2 columns. Precipitation figures in general show rather close negative correlation with those for temperature, but they are less reliable, because local storms on comparatively narrow fronts may give an untrue picture.

The percentage possible sunshine is also less reliably associated with the population than temperature, in that it was made at a single, central point rather than at several, scattered points within the study area. A relationship with the following season's population is suggested by the high *r* values for August and September at the most arid and southerly stations, Swift Current and Moose Jaw.

Snowfall in inches, cloud by percentage cover, and wind by direction and milage are also reported by the Meteorological Division. No use was made of snowfall or cloud figures. Regardless of snow cover, eggs of *M. m. mexicanus* are usually unharmed by frost (8), and snow represents only about one-fifth of the annual precipitation with little effect on

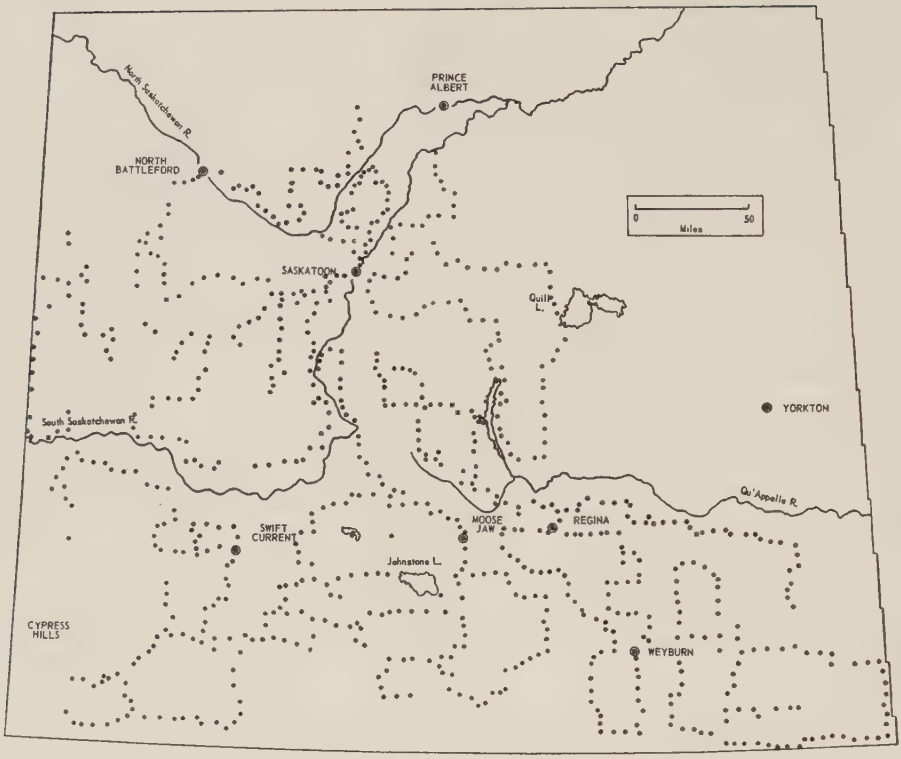

FIGURE 8. Points at which populations of *M. m. mexicanus* were sampled during adult survey of southern Saskatchewan, 1952.

vegetation (13). Exploratory study of cloud cover showed weak negative correlation, holding little promise of new information, at least of a species such as *M. m. mexicanus*, which is rarely attacked by fungi. Negative values for correlation coefficients between population and wind velocity in the current June indicate that prolonged high winds are probably detrimental to the species. The two possible sets of coefficients were worked out, i.e., for Swift Current, and the station average over the Province. Values of r for the current June were respectively $-.640^*$ and $-.444$. Other values calculated for wind velocity were well below significance.

Of evaporation Thornthwaite (17) stated in 1940: "The problem of atmospheric moisture in relation to ecological problems is still far from being solved", and concluded: "More satisfactory instruments . . . must be devised". In 1954 Langbein and Harbeck (6) noted: "The lack of a direct method of measurement of evaporation from large land and water areas constitutes one of the basic gaps in hydrologic inventory." It is clear that not much weight can yet be placed upon any evaporation figures.

Since the weather factors vary together, a multiple correlation analysis was made, based on the highest values of r for those factors reported monthly and hence quickly available. The objective was a quantitative basis for predicting populations, from data available during the winter.

TABLE 5.—CORRELATION COEFFICIENTS OF VARIOUS WEATHER FACTORS DURING SEPTEMBER WITH POPULATIONS OF *M. m. mexicanus* ADULTS THE FOLLOWING SEASON IN THE AREAS STUDIED.

Factor	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current	Pooled *r*	χ^2
Mean monthly temperature	.002	.351	.327	.408	.700*	.363	2.682
Maximum monthly temperature	.116	.336	.358	.506	.753*	.422	2.841
Minimum monthly temperature	−.198	.352	.408	.109	.407	.213	2.102
Per cent possible sunshine	.604	.373[1]	.605	.625	.703*	.569	0.902
Evaporation (Meyer ratio P/V.P.D.)	−.077	−.050	.038	−.617	−.648*	−.318	4.303
Precipitation	−.051	−.148	.099	−.558	−.659*	−.373	4.166
Vapour pressure deficit	.153	.368	.316	.247	.698*	.359	2.119
Evaporation (open tank)		.292[1]			.709*		

* Significant at 5 per cent level.
[1] Sunshine and evaporation were not recorded at North Battleford but at Scott, 33 miles southwest.

TABLE 6.—CORRELATION COEFFICIENTS OF VARIOUS WEATHER FACTORS DURING JUNE WITH POPULATIONS OF *M. m. mexicanus* ADULTS IN THE SAME SEASON IN THE AREAS STUDIED.

Factor	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current	Pooled r	χ^2
Mean monthly temperature	.481	.690*	.499	.626	.295	.501	1.137
Maximum monthly temperature	.460	.646*	.650*	.415	.228	.472	1.458
Minimum monthly temperature	.131	.463	.255	.303	.261	.272	0.503
Per cent possible sunshine	.058	.704[1]*	−.221	−.223	.011	.094	5.776
Evaporation (Meyer ratio P/V.P.D.)	−.002	.369	−.437	−.611	−.347	−.239	4.427
Precipitation	.019	−.135	−.165	−.481	−.459	−.244	1.645
Vapour pressure deficit	.507	.479	.335	.597	.156	.404	1.022
Evaporation (open tank)		.512[1]			.175		

* Significant at 5 per cent level.
[1] Sunshine and evaporation were not recorded at North Battleford but at Scott, 33 miles southwest.

The resultant planes with four variables did not describe the data well. The variables were: *one*, log $(x + 1)$ population; *two*, mean monthly temperature; *three*, hours of bright sunshine; and *four*, total precipitation. Simple correlation, using variables *one* and *two* only, gave significant values for more of the areas, but the coefficients were not high enough to be used in prediction.

	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current
Multiple correlation, $r_{1.234}$	.845*	.768	.850*	.824	.813
Simple correlation, $r_{1.2}$	.744*	.610	.655*	.790**	.702*

Table 7 shows the association between single factors and subsequent populations, one other factor being held constant in each case. It illustrates the comparative unimportance of precipitation, especially in the three southernmost areas. The values are calculated from the simple correlations for single months having the highest values (Table 8).

Table 9 shows the increases in mean monthly temperature associated with an increase of one unit in the population index. With few exceptions, both the increases and their standard errors of estimate were rather uniform and well described by the means and the over-all average. The shifts in mean temperature that were followed by appreciable population changes were notably small.

TABLE 7.—PARTIAL CORRELATION COEFFICIENTS FOR POPULATIONS OF *M. m. mexicanus* ADULTS AND SINGLE WEATHER FACTORS WHEN ONE OTHER FACTOR IS HELD CONSTANT, EACH CONSIDERED DURING THE MONTH OF ITS HIGHEST SIMPLE CORRELATION.

Factor	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current
Temperature with sunshine constant	.584	.741*	.415	.524	.162
Temperature with rainfall constant	.550	.520	.743*	.726*	.281
Sunshine with temperature constant	.258	−.573	.422	.172	.534
Sunshine with rainfall constant	.413	.066	.745*	.520	.146
Rainfall with temperature constant	.554	−.048	.546	−.365	−.579
Rainfall with sunshine constant	.647*	−.294	.538	−.045	−.233

* Significant at 5 per cent level.

TABLE 8.—MONTHLY WEATHER FACTORS IN PREVIOUS YEAR USED IN MULTIPLE CORRELATION ANALYSIS FOR CALCULATION OF POPULATION INDEXES.

Factor	Prince Albert	North Battleford	Saskatoon	Moose Jaw	Swift Current
Mean temperature in degrees F.	June	Aug.	Aug.	Aug.	Aug.
Hours of bright sunshine	Sept.	Aug.	Sept.	Aug.	Aug.
Total precipitation in inches	Aug.	July	June	Sept.	Aug.

To deduce a causal relationship merely from the evidence of a high value of r would be a fallacy in logic. However, simple correlation shows the strength of any linear relationship between the weather factors and later adult populations. The relationship may be causal when the weather factors chosen, such as maximum temperatures, are of proved influence on grasshopper reproduction (8) and occur during critical periods in the seasons previous to those of the adult populations.

Factors other than weather affect populations of *M. m. mexicanus*, but no quantitative assessment of most of these has yet been made. The most obvious are: disease; predation and parasitism, some forms of which become of increasing importance as an outbreak progresses (9); cultural control; and perhaps most important, chemical control. In the decade under study chlorinated hydrocarbons were introduced, some of them constituting the greatest weapons against grasshoppers yet found. Their over-all quantitative effect can be only guessed.

Still another factor is diet. The degree of dietary choice exercised by *M. m. mexicanus* is difficult to demonstrate under natural conditions, although the effects of various food plants on growth and reproduction have been shown to differ under cage conditions. Scharff (14) has reviewed the literature, concluding that preference and favourability are associated. His contention that any grasshopper population is the direct product of the food plants present, and the indirect product of the weather producing the plants, does not weaken the argument presented here, that there appears to exist a casual, linear relationship between weather and subsequent populations of *M. m. mexicanus* in Saskatchewan.

The coefficients of variation among observed populations show that high variation is present; data for a longer period would not reduce this, but would increase the reliability of the coefficients. Statistical prediction of populations is unlikely to be more than confirmatory and supplementary to the system of forecasting used now. Any predicted increase or decrease, expressed as an index number, would have to be broken down and shown on a map in terms of populations, the distribution of which would be based on those of the previous year. This is, in effect, very similar to the system for producing forecast maps at present in use on the Canadian prairies.

TABLE 9.—CHANGES IN MEAN MONTHLY TEMPERATURE IN DEGREES F. ASSOCIATED WITH A CHANGE OF 1 UNIT IN THE POPULATION INDEX OF *M. m. mexicanus* IN THE AREAS STUDIED.

Month	Prince Albert		North Battleford		Saskatoon		Moose Jaw		Swift Current		Mean	
	°F.	S.E.[1]	°F.	S.E.	°F.	S.E.	°F.	S.E.	°F.	S.E.	°F.	S.E.
Previous June	.13	1.4	.02	2.5	.03	1.5	.03	1.7	.04	2.3	.05	1.9
Previous July	.09	1.9	.03	1.9	.02	2.4	.02	2.0	.02	2.5	.04	2.1
Previous August	.08	1.7	.07	1.8	.04	1.7	.05	1.7	.05	1.9	.06	1.8
Previous September	.00	2.3	.04	2.4	.02	2.3	.02	2.4	.07	2.3	.03	2.3
Current June	.08	1.8	.11	1.9	.03	1.8	.04	1.4	.02	1.9	.06	1.8
Mean	.08	1.8	.05	2.1	.03	1.9	.03	1.8	.04	2.2	.05	2.0

[1] Standard error of estimate.

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GONADOTROPHINS OF BOVINE BLOOD AND URINE[1]

T. S. Foster

Canada Department of Agriculture, Ottawa

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ABSTRACT

Extracts of bovine blood and urine were assayed for gonadotrophic titre by means of the seminal vesicle weight response of immature rats. No gonadotrophic activity was detected in extracts of samples from non-pregnant cows and from three cows during the first 15 weeks of gestation.

Evidence is presented which indicates that exogenous chorionic gonadotrophin is rapidly inactivated in the cow. The inactivation is more complete in the bovine than in other species.

INTRODUCTION

A reliable diagnosis which could be applied early in pregnancy in cattle would be valuable to both the veterinarian (16) and the breeder (5). Some tests in other species are based on the marked rise in gonadotrophic titre in blood and urine. In their comprehensive reviews, Cowie (8) and Cuboni (9) report that gonadotrophic hormones have been demonstrated in the anterior pituitary of the cow but not in placenta, endometrium or amniotic fluid, nor in the milk or saliva of the pregnant cow. Tests based on the gonadotrophic hormone of bovine blood and urine have not been successful. Such bio-assays included tests with immature female mice and rats, female guinea pigs, rabbits and frogs (*Xenopus laevis*), immature male mice and male rabbits. Cowie (8) believed that gonadotrophins, if they existed in blood or urine of the pregnant cow, were not present in a form which could be detected by the usual biological methods.

More sensitive tests have been developed since Cuboni's review in 1949, and it was decided to investigate the application of these together with the use of more recent extraction procedures as a basis for pregnancy diagnosis.

METHODS AND MATERIALS

Gonadotrophins

The chorionic and seric gonadotrophins[2] were obtained in vials which were reported to contain 1000 International Units (I.U.). Standard solutions containing 0.5, 1.0 and 2.0 I.U. of the desired hormone per 0.1 ml. were prepared in physiological saline not more than 24 hours prior to an assay. In order to minimize the degradation of the hormones, the solutions were stored in the refrigerator when not in use.

Chemical Tests

The following chemical tests were investigated both on solutions of the hormones and on bovine pregnancy urines: the test of Van den Driessche and Hans (30) for the reaction of orcinol with gonadotrophins; Richardson's test (27) based on the brown colour which free oestrone produces with 2,4-dinitrophenylhydrazine; and the Cuboni test, as modified by Roth, Mayer and Bogart (29) for oestrogenic activity in pregnancy urines.

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[1] Contribution No. 317, Chemistry Division, Science Service, Canada Department of Agriculture, Ottawa.

[2] Bios Laboratories Inc., New York, N.Y.

Collection and Preparation of Samples

Approximately one litre of blood was collected from the jugular vein into oxalated flasks. The plasma was removed, measured, and preserved by freeze-drying. In preparation for assay the dried sample was extracted using the technique of Cole and Goss (6) and the final precipitate was dissolved in 10 ml. of physiological saline. Two ml. of this solution was diluted to 8 ml. with saline and both solutions were stored in the refrigerator for not more than 24 hours before they were assayed.

Approximately one gallon of urine was collected by catheterization (10). The urine was kept cold until it could be processed but no preservative was added. The filtered urine was brought to pH 5.6 and mixed with two volumes of cold acetone (26). The resulting precipitate was washed once with cold acetone and once with cold diethyl ether, dried and stored in the refrigerator. In preparation for assay, the dried powder was extracted three times with 50 ml. aliquots of ice-cold 0.1 M phosphate buffer, pH 7.8, by mechanical shaking. The combined extracts were treated by the method of Lyon, Simpson and Evans (22) and the final extract was diluted to 50 ml. with physiological saline. Ten ml. of this solution was diluted to 40 ml. with saline and both solutions were stored in the refrigerator for not more than 24 hours before they were assayed.

Experimental Animals

(a) *Preliminary.* The following biological tests were investigated for the limit of their sensitivity to gonadotrophins as the basis of suitability as a pregnancy test for the cow: the liberation of spermatozoa (28) by male leopard frogs (*Rana pipiens*) which were obtained from a local source* and maintained in the refrigerator as suggested by Hodgson (20); the increased ovarian weights (7) of immature female rats (21-25 days old); and the increased testes weights (21) of day-old male chicks (NH x BR).

(b) *Immature male rats.* The technique of Diczfalusy (12) was modified for use as an assay procedure for bovine gonadotrophins. Weanling male rats, 21-25 days old, were weighed and those which exceeded the mean body weight by more than two standard deviations were discarded. The rats were randomly distributed to the various cages with access to rat cubes and water. The rats were injected subcutaneously on each of three consecutive days with 0.1 ml. of saline solutions of the standard gonadotrophins or extracts to be assayed. When extracts of blood were assayed, seric gonadotrophin was used as the standard and when extracts of urine were assayed, chorionic gonadotrophin was used. A group of control rats and three groups of gonadotrophin-treated rats (total dose 0.0, 1.5, 3.0 and 6.0 I.U.) were included with each assay.

On the fourth day, 72 hours after the first injection, the rats were asphyxiated with ether and the urogenital tract removed, banded and placed in Bouin's solution. Twenty-four to 48 hours later, the seminal vesicles were dissected free from the other organs, dried on blotting paper and weighed on a precision balance.

*Kopp Laboratories Ltd., Ottawa, Canada.

RESULTS

(*a*) *Preliminary*

The male leopard frog reacted positively by liberation of spermatozoa to 35 I.U. of chorionic gonadotrophin; the immature female rat responded by a significantly increased ovarian weight to 10 I.U. of seric gonadotrophin; and the day-old chick responded by an increased testes weight to 21 I.U. of either chorionic or seric gonadotrophin. The chemical test of Van den Driessche and Hans (30) did not yield the typical mauve colour with as much as 800 I.U. of chorionic gonadotrophin.

In addition, Richardson's test gave negative results with bovine pregnancy urine although it yielded positive results when oestrone was added to the urine. Also the Cuboni test as modified by Roth, Mayer and Bogart (29), although it can detect 400 rat units or more of oestrogens per 10 ml. of urine, gave negative results during the first fifteen weeks of gestation.

(*b*) *The Immature Male Rat for the Bio-assay of Gonadotrophins*

None of these tests was considered sufficiently sensitive to detect the small quantities of hormones which were believed to be present in bovine blood and urine. However, the reproductive and accessory reproductive organs of the immature male rat had been used successfully for the quantitative assay of human chorionic gonadotrophin (11, 12, 13). Diczfalusy and Loraine (14) made a statistical evaluation of various techniques and reported that this assay, using litter-mate rats, was more sensitive than and twice as precise as previously reported methods.

TABLE 1.—THE RESPONSE OF THE SEMINAL VESICLES OF IMMATURE MALE RATS TO SERIC GONADOTROPHIN*

Total Dose (I.U.)	No. of Rats	Seminal Vesicles** (mgm.)
—Litter-mates (33-42 gm.)—		
0.0	22	4.6 ± 2.1
1.5	23	5.7 ± 1.6
3.0	24	9.4 ± 1.7
6.0	24	13.1 ± 2.5
—Litter-mates (16-48 gm.)—		
0.0	10	6.2 ± 1.6
1.5	10	7.3 ± 1.4
3.0	9	9.2 ± 1.8
6.0	10	14.7 ± 3.4
—Non-litter-mates (16-48 gm.)—		
0.0	19	5.7 ± 0.9
1.5	20	8.7 ± 3.1
3.0	17	12.0 ± 3.1
6.0	20	15.4 ± 3.1

*Gonadotrophin Seric Hormone (Bios Laboratories Inc., New York).
**Mean ± standard deviation.

TABLE 2.—THE RESPONSE OF THE SEMINAL VESICLES OF IMMATURE MALE RATS TO CHORIONIC GONADOTROPHIN*

Total Dose (I.U.)	No. of Rats	Seminal Vesicles** (mgm.)
—Litter-mates (33-42 gm.)—		
0.0	15	6.6 ± 1.6
1.5	14	11.1 ± 3.8
3.0	15	16.4 ± 3.1
6.0	14	16.9 ± 3.8
—Litter-mates (16-48 gm.)—		
0.0	8	6.1 ± 1.2
1.5	8	11.7 ± 2.0
3.0	8	17.3 ± 3.5
6.0	8	16.6 ± 4.1
—Non-litter-mates (16-48 gm.)—		
0.0	9	6.3 ± 2.3
1.5	8	12.3 ± 3.1
3.0	8	14.1 ± 3.6
6.0	9	17.1 ± 2.8

*Chorionic Gonadotrophin (Bios Laboratories Inc., New York).
**Mean ± standard deviation.

Preliminary to application of this assay to the cow, experiments were designed to test the significance between the response of litter-mates and non-litter-mates and the significance of initial body weight of the rats when used in the assay. Both seric and gonadotrophin at total dosage levels of 1.5, 3.0 and 6.0 I.U. were investigated. For each gonadotrophin three groups of rats were chosen, litter-mates with a body weight of 33-42 gm., litter-mates weighing 16-48 gm., and non-litter-mates weighing 16-48 gm. The results are shown in Tables 1 and 2.

Analyses of variance performed on the data showed that, for neither of the gonadotrophins was there a statistically significant difference in response, either between litter-mates and non-litter-mates or between litter-mates of different initial body weights.

A statistically significant ($P < 0.05$) positive correlation was found to exist between both initial and final body weights and the seminal vesicle weights in the control rats. However, no significant correlation was found to exist at any of the dosage levels of either gonadotrophin. Therefore, adjustment of organ weight by proportionality would not increase the precision of the method. This is in agreement with Diczfalusy (12).

The sensitivity of the assay was the same as that reported by Diczfalusy (12) in that it could detect as little as 1.5 I.U. of either gonadotrophin. Therefore, on the basis of concentrating the urine samples to a volume of 50 ml. and the blood samples to 10 ml., the assay could detect as little as 250 I.U. per gallon of urine or 50 I.U. per litre of blood.

TABLE 3.—THE RESPONSE OF THE SEMINAL VESICLES OF IMMATURE MALE RATS TO EXTRACTS OF BOVINE PLASMA AND URINE

Stage of Gestation (week)	Seminal Vesicles[1]	
	Plasma	Urine
Control Rats	6.5 ± 1.8[2]	6.1 ± 1.5[4]
Not Pregnant	5.7 ± 1.4[3]	5.7 ± 1.3[5]
—Cow A—		
1st.	7.7 ± 1.6	—
4th.	7.2 ± 1.5	—
7th.	6.9 ± 2.1	—
10th.	6.6 ± 1.8	—
13th.	6.8 ± 1.2	—
—Cow B—		
2nd.	7.3 ± 1.2	5.5 ± 1.0
8th.	7.5 ± 2.0	5.4 ± 0.7
11th.	7.7 ± 1.5	—
14th.	7.1 ± 2.1	5.3 ± 0.6
—Cow C—		
3rd.	6.0 ± 1.7	6.5 ± 1.4
6th.	7.8 ± 2.0	—
9th.	7.4 ± 1.6	±
12th.	7.9 ± 1.8	—

[1] Mean ± standard deviation.
[2] Combination of data for 5 assays.
[3] Combination of data for 8 samples.
[4] Combination of data for 5 assays.
[5] Combination of data for 10 samples.

(c) The Assay of Extracts of Blood and Urine from the Cow

Blood and urine samples were collected from three cows during the early stages of gestation. The collection times were arranged as follows: Cow A*—1st, 4th, 7th, 10th and 13th week of gestation; Cow B*—2nd, 5th, 8th, 11th and 14th week; Cow C*—3rd, 6th, 9th, 12th and 15th week. Samples were collected from Cow C before conception and also from two other non-pregnant cows.

The results of the assays are shown in Table 3. Analysis of the data showed that there was no statistically significant increase in seminal vesicle weights due to injections of extracts of bovine blood or urine. Therefore, there was less than 250 I.U. of material with gonadotrophic activity in one gallon of urine and less than 50 I.U. per litre of blood collected from non-pregnant cows and from pregnant cows during the first 15 weeks of gestation.

(d) The Recovery of Exogenous Chorionic Gonadotrophin from the Cow

The results of the assays of blood and urine indicate that either very little gonadotrophin is produced by the cow or that the hormone is metabolized at a greater rate than in other animals. Therefore, an attempt

* The pregnancy of these cows has been confirmed.

TABLE 4.—THE GONADOTROPHIC TITRE OF BLOOD AND URINE SAMPLES FROM A HEIFER INJECTED WITH 3000 I.U. CHORIONIC GONADOTROPHIN

Sample	Total Volume Extracted (ml.)	Seminal Vesicles* (mgm.)
0.0 I.U. CG**	—	7.3 ± 1.5
1.5 I.U. CG	—	9.0 ± 1.5
3.0 I.U. CG	—	14.5 ± 3.1
6.0 I.U. CG	—	16.4 ± 2.7
8-hour Urine	2300	13.5 ± 2.8
8-hour Blood	1000	10.6 ± 1.4
24-hour Blood	1000	7.0 ± 1.4
48-hour Urine	2590	8.3 ± 1.6
48-hour Blood	250	6.3 ± 1.0

*Mean ± standard deviation.
**Chorionic gonadotrophin.

was made to see whether injected gonadotrophins could be recovered from the blood or urine.

Although gonadotrophins have been injected into cows and heifers in the treatment of functional sterility (18) and in superovulation experiments (15, 23, 24, 31) no data have appeared on the recovery of gonadotrophins from blood and urine.

A normal heifer of breeding age, weighing 750 lb., was catherized (10) and then given a 5 ml. injection of 3000 I.U. of chorionic gonadotrophin via the jugular vein. One litre of blood was collected at 8, 24 and 48 hours after the injection. The urine which had been passed during these intervals was also collected (unfortunately the 24-hour sample was lost). The blood and urine samples were treated as above and the results of the assay are shown in Table 4.

Analysis of the data indicated statistically significant responses from both the blood and urine samples collected 8 hours after the injection. By an estimate of total blood volume based on the body weight, it was calculated that 34 to 56 per cent of the injected chorionic gonadotrophin was still circulating in the blood at 8 hours, while 2 to 6 per cent had been excreted in the urine. However, no activity could be measured at the 24- and 48-hour periods.

Zondek and Sulman (33) report that after a single subcutaneous injection of chorionic gonadotrophin into a rat recoveries were: 50 per cent at 1 hour, 25 per cent at 8 hours and 10 per cent at 24 hours from blood; 1 per cent at 4 hours and 2 to 5 per cent at 20 hours from urine. In man the recoveries were: 30 per cent from blood and 10 to 20 per cent from the urine at 24 hours. In the gelding they were 13.5 per cent from the blood and 5 per cent from the urine at 24 hours. The results of the above-mentioned experiment indicate that the cow is able to inactivate gonadotrophin rapidly and more completely than the three species mentioned above.

DISCUSSION

The problem of a suitable test for bovine pregnancy which would greatly benefit the cattle breeder remains unsolved. All attempts to utilize existing techniques or modifications of them based on the sex hormones of pregnancy have proved unsuccessful.

The bovine appears to be a most peculiar species from a hormonal viewpoint. Asdell (2) summarized some of the facts which are known about the cow. Domestic cattle are polyoestrous, breeding all the year. Ovulation is spontaneous and occurs at intervals of about 21 days. Oestrus lasts for less than one day and the cow goes out of oestrus before it ovulates. Uterine changes during the cycle are not marked and the vaginal smear is not a very reliable indication of the reproductive state.

The cow appears to have the lowest sex-hormone output and requirement of all the domestic animals. The bovine pituitary has a very low luteinizing hormone content and the lowest recorded follicle stimulating hormone content (32). The urinary excretion of oestrogens (4, 19, 25) and pregnanediol (17) during pregnancy is very low. The amount of oestrogen required to bring the cow into oestrus is also extremely small for so large an animal (1, 3). Gonadotrophin requirements appear to be low both for the treatment of functional infertility (18) and in superovulation processes (15, 23, 24, 31).

The fact that no gonadotrophic activity has been detected in bovine blood or urine during the early stages seems to be related to two factors: (1) The output of gonadotrophin is very small because the gonadotrophic content of the anterior pituitary and the requirements for the hormone are very low; (2) The cow has a very excellent system for the inactivation of gonadotrophin. The mechanism of this system and the mode of inactivation are equally unknown. Therefore, the possibility of an early pregnancy test based on gonadotrophin would seem to be dependent on a more thorough understanding of this process and an investigation of the metabolites or inactivated form of gonadotrophin.

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AVAILABILITY OF PHOSPHORUS IN SOILS PRE-TREATED WITH SUPERPHOSPHATE[1]

R. L. Halstead, A. J. MacLean and L. E. Lutwick

Canada Department of Agriculture, Ottawa

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ABSTRACT

In a greenhouse experiment different rates of superphosphate were incorporated in nearly neutral surface soil samples from three farms on each of three soil types, and after the treated soil was kept moist for a 6-week period, alfalfa was grown during a 2-year period. The uptake of phosphorus by the crop increased with increasing rates to 2000 lb. (P_2O_5) per acre, the highest rate employed. The average phosphorus content of the plants grown in the first year increased from 0.18 per cent without superphosphate to 0.54 per cent with the heaviest application, a pre-treatment of 2000 lb. (P_2O_5) per acre.

The amounts of Truog acid-soluble, Bray adsorbed, and $NaHCO_3$-soluble phosphorus in the untreated samples were correlated with "a" values calculated from regression equations relating the uptake of phosphorus by the crop in the first year to the phosphate pre-treatments.

In terms of acid-soluble, adsorbed, $NaHCO_3$-soluble, and water-soluble phosphorus, the recovery per unit of added phosphate increased in most instances with increasing rates. The amounts of Bray adsorbed and of $NaHCO_3$-soluble phosphorus in the same samples were similar. The average recovery of phosphate added to the soils at the rate of 200 lb. (P_2O_5) per acre was 42 per cent for acid-soluble phosphorus and 35 per cent for $NaHCO_3$-soluble phosphorus. The amounts of water-soluble phosphorus were higher than those obtained by extraction with a 0.01 M $CaCl_2$ solution. The variations in soluble phosphorus occurring between the different soil samples were similar for the water and salt solution.

INTRODUCTION

Certain slightly acid to mildly alkaline soils in the Ottawa district were shown previously (7) to have a relatively low capacity to supply phosphorus. In the fall of 1952, studies were begun to ascertain the availability of added phosphate in these soils.

The reactions of phosphate with soil have been discussed recently by Kurtz (6) and Olsen (8). The soils used in the present investigation represented the surface layer of cultivated fields of three farms on each of three soil types. The availability of added superphosphate in greenhouse tests was assessed on the basis of the uptake of phosphorus by alfalfa and the amounts of phosphorus extracted from the treated soils using different chemical procedures.

EXPERIMENTAL PROCEDURE

Fields to which phosphorus fertilizer had not been applied in large amounts were selected on three farms on each of Castor silt loam, Grenville loam, and Carp clay loam (4). The soils from which the samples were collected are described briefly as follows: (1) Castor silt loam, a poorly drained, dark grey gleisolic soil; (2) Grenville loam, a well drained, brown forest soil on till; (3) Carp clay loam, an imperfectly drained,

[1] Presented before Canadian Soil Science Society, Edmonton, Alberta, June 21, 1955. Joint contribution from the Chemistry Division, Science Service, and the Division of Field Husbandry, Soils and Agricultural Engineering, Experimental Farms Service. (Contribution No. 322, Chemistry Division).

weakly developed, grey brown podzolic soil. Composite samples to plough depth were obtained from each of the fields. Under field conditions, alfalfa is adapted to Grenville loam and Carp clay loam but not to Castor silt loam where drainage is poor.

The samples were air-dried, passed through a half-inch sieve and mixed. Ten-pound lots of soil were placed in glazed one-gallon pots. In December 1952 superphosphate (20 per cent P_2O_5) was applied with thorough mixing to each soil at rates equivalent to 0, 50, 100, 200, 350, 600, 1000, and 2000 lb. P_2O_5 per acre. These applications, designated as pre-treatments, were replicated nine times. After keeping the soils moist for a period of 6 weeks, inoculated Grimm alfalfa was seeded and, at the same time, additional superphosphate (100 lb. P_2O_5 per acre) was applied to three replications of the pre-treatments. The stand of alfalfa was thinned to ten plants per pot and four cuttings were made in the bloom stage during 1953. The pots which had received additional phosphate at the time of seeding were discarded after the fourth cutting. The remaining pots were reseeded in December 1953, at which time additional superphosphate (100 lb. P_2O_5 per acre) was applied to the pre-treated soils in three of the replications at the time of seeding. The other three replications were retained without further addition of phosphate. Four cuttings of alfalfa were made in 1954.

Potassium chloride (200 lb. K_2O per acre) was applied to all pots in both years. The applications of potassium fertilizer and of superphosphate at the time of seeding were made in a layer at a depth of 2 inches from the surface of the soil. The treatments were randomized. The yield data represent the total air-dry material from the four cuttings each year.

Composite samples of the plant material obtained from all replications of each treatment each year were ground in a Wiley mill. Their phosphorus content was determined by the method of King (5) after wet digestion with sulphuric, nitric and perchloric acids as described by Piper (10).

Composite samples were made of the soil from replicate pots before seeding alfalfa in the first year and after the final cutting in the second year. These were air-dried and passed through a 2-mm. screen. The pH of the soil was obtained by means of a glass electrode using a 1:1 soil: water ratio. The total phosphorus content of the soil was determined by the method of Shelton and Harper (11). Easily soluble phosphorus was measured as follows: (a) acid-soluble phosphorus extracted with 0.002 N H_2SO_4 (pH 3.0) according to Truog (12); (b) adsorbed plus acid-soluble phosphorus extracted with 0.03 N NH_4F in 0.10 N HCl, using the procedure described by Bray (1); (c) adsorbed phosphorus only, extracted with 0.03 N NH_4F in 0.025 N HCl, as described by Bray (1); (d) acid-soluble phosphorus representing the difference between values for methods (b) and (c); (e) phosphorus extracted with 0.05 N $NaHCO_3$ following the procedure of Olsen *et al.* (9); (f) water-soluble phosphorus by shaking a 1: 2.5 soil : water suspension for a 24-hour period and determining the phosphorus in the extract by the procedure of Dickman and Bray (3); and (g) the phosphorus soluble in a salt solution using a procedure similar to (f) except that 0.01 M $CaCl_2$ was employed instead of water.

RESULTS AND DISCUSSION

Yield and Phosphorus Content of Alfalfa

The mean yield and phosphorus content of alfalfa are shown in Table 1 for each pre-treatment on each soil type. The uptake of phosphorus from pre-treated pots has been expressed as a percentage of the uptake from corresponding pots to which additional superphosphate was applied at seeding.

The yield of alfalfa in the first year increased markedly with increase in rates to about 350 to 600 lb. (P_2O_5) per acre. Although there was a trend, particularly on Carp clay loam, for still higher yields to occur as the rate was raised to 2000 lb. (P_2O_5) per acre, the differences were slight considering the high amounts of phosphate applied. In the second year of cropping the yield increased with increasing rates to 2000 lb. (P_2O_5) on the Grenville and Carp soils and to 1000 lb. (P_2O_5) on the Castor soil. With a rate of 2000 lb. (P_2O_5) on the latter soil, there was a reduction in yield from that obtained with 1000 lb. (P_2O_5) per acre.

TABLE 1.—THE YIELD AND PHOSPHORUS CONTENT OF ALFALFA IN SOILS PRE-TREATED WITH SUPERPHOSPHATE AND THE RESULTING UPTAKE OF PHOSPHORUS RELATIVE TO THAT IN A CORRESPONDING SERIES RECEIVING ADDITIONAL PHOSPHATE AT THE TIME OF SEEDING

(Means for 3 tests on each soil type; air-dry material from 4 cuttings per pot)

Pre-treatment (P_2O_5/acre)	Yield	P content	Yield	P content	Uptake of P*	
	1st yr.	1st yr.	2nd yr.	2nd yr.	1st yr.	2nd yr.
lb.	gm.	%	gm.	%	%	%
			Castor silt loam			
0	34.5	0.16	15.2	0.15	45	30
50	47.9	0.18	19.6	0.15	55	35
100	58.1	0.19	22.2	0.15	59	42
200	68.0	0.24	26.3	0.17	75	48
350	76.0	0.28	33.5	0.19	84	64
600	80.3	0.35	42.0	0.24	90	75
1000	80.3	0.44	50.2	0.29	92	92
2000	82.0	0.61	45.5	0.45	106	84
			Grenville loam			
0	30.1	0.17	15.7	0.17	44	39
50	46.7	0.18	16.3	0.17	60	38
100	59.9	0.18	19.5	0.18	68	45
200	69.5	0.22	28.0	0.18	71	58
350	77.1	0.26	37.6	0.18	84	67
600	89.8	0.31	48.7	0.22	93	79
1000	89.0	0.37	53.4	0.28	91	94
2000	95.5	0.49	57.3	0.33	126	93
			Carp clay loam			
0	55.6	0.20	29.1	0.17	65	47
50	67.9	0.22	29.8	0.18	71	53
100	75.9	0.24	32.0	0.18	81	54
200	83.3	0.27	38.1	0.18	88	63
350	91.3	0.30	44.1	0.21	87	74
600	99.7	0.35	50.3	0.24	94	80
1000	104.4	0.41	54.5	0.26	96	86
2000	110.3	0.53	65.8	0.35	98	92
L.S.D. (0.05)	6.7		3.8			

* The uptake of P for pre-treatment only is expressed as a percentage of the uptake for a series receiving additional P (100 lb. P_2O_5/acre) when seeding each year.

TABLE 2.—PHOSPHORUS SUPPLY IN THE UNTREATED SOILS AS SHOWN BY "a" VALUES, TOTAL PHOSPHORUS CONTENT, AND THE AMOUNTS OF AVAILABLE PHOSPHORUS DETERMINED BY DIFFERENT CHEMICAL METHODS

Sample	"a" values Pre-treat. (lb. P_2O_5/ac.) 0 to 350	0 to 2000	pH	Total P	Acid-sol. P Truog)	Acid-sol. + ads. P (Bray)	Adsorbed P (Bray)	$NaHCO_3$-sol. P (Olsen)	Water-soluble P
	lb. P_2O_5/ac.			%	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
				Castor silt loam					
O	94	192	7.6	0.14	153	133	13.9	8.5	0.12
C	93	218	6.7	0.13	95	95	13.5	9.6	0.53
P	46	101	6.6	0.08	119	74	4.9	4.9	0.06
				Grenville loam					
C	138	360	7.4	0.11	67	55	10.0	12.1	0.16
S	62	126	7.2	0.08	41	24	2.4	3.4	0.11
G	66	97	7.0	0.06	38	16	2.8	3.4	0.03
				Carp clay loam					
L	244	618	6.7	0.11	248	126	24.1	23.6	0.32
G	101	314	6.3	0.13	156	87	18.4	14.4	0.27
B	103	168	6.9	0.10	155	74	10.0	9.0	0.13
Correlation coefficients:									
"a" values (0-350 lb.) vs. soil P				0.346	0.708*	0.532	0.806*	0.938*	0.406
"a" values (0-2000 lb.) vs. soil P				0.334	0.633	0.495	0.830*	0.893*	0.445

* Significant at 0.05

The phosphorus content of the alfalfa increased considerably as a result of the phosphate pre-treatments. On Castor silt loam, where the greatest variation in plant composition occurred, the phosphorus content of the plants in the first year increased to 0.61 per cent where the highest rate of phosphate was used. This represented nearly a fourfold increase over the value obtained for the plants grown without phosphate fertilizer. As the yield on the different soils approached a maximum in relation to the rates of pre-treatments, the phosphorus content of the plants was about 0.30 per cent or slightly higher.

Only at the higher rates of the pre-treatments did the uptake of phosphorus by the plants approach the uptake in a corresponding series receiving additional phosphorus at seeding. With a pre-treatment of 600 lb. (P_2O_5), the uptake of phosphorus from the different soils in the first year was 90 to 94 per cent and in the second year 75 to 80 per cent of the uptake in the series receiving additional phosphate.

Phosphorus in Untreated Soils

The data for uptake of phosphorus by alfalfa provided a basis for estimating the phosphorus supply in the untreated soils in terms of "a" values as discussed by Dean (2). With a plot of the phosphate pre-treatments on the X axis and the uptake of phosphorus on the Y axis, the "a" value represents the intercept of the curve on the X axis as calculated from the equation for the curve. In Table 2, "a" values based on the phosphorus uptake in the first year for rates up to 350 and 2000 lb. (P_2O_5) are compared with the values for total soil phosphorus and with the amounts of phosphorus extracted from the untreated soils using the same chemical procedures employed for measuring the phosphorus supply in the soils pre-treated with phosphate. The pH values for the soils are included in the table.

The "a" values computed from the uptake data for all rates were considerably higher than the corresponding values for the five lower rates not exceeding 350 lb. (P_2O_5) per acre. As will be shown later (Table 3) the slope of the curves for uptake of phosphorus decreased with increasing rates of phosphate pre-treatments.

The "a" values and the results obtained with the different chemical methods show that there were certain consistent variations between samples from different farms on the same soil type. For example, higher values were obtained for sample O than for P of Castor silt loam, for sample C than for G of Grenville loam, and for sample L than for B of Carp clay loam. The methods for adsorbed and $NaHCO_3$-soluble phosphorus tended to give similar results for the same samples. The value for water-soluble phosphorus in the C sample of Castor silt loam was relatively high compared with those found for the other samples. On the basis of the few data available, the correlation coefficients showing the relationship between either set of "a" values and the amounts of $NaHCO_3$-soluble, adsorbed, and Truog acid-soluble phosphorus were significant in all but one instance. The highest coefficients were obtained for $NaHCO_3$-soluble phosphorus.

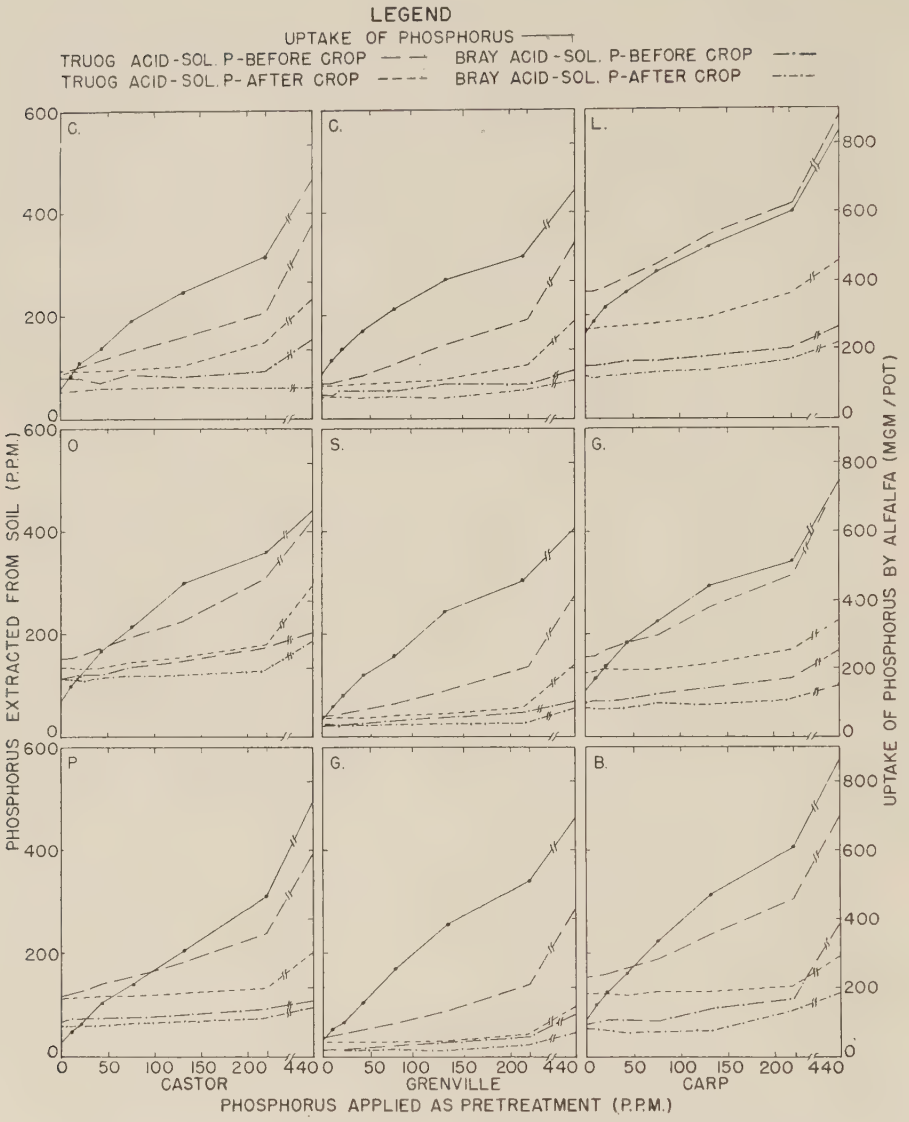

FIGURE 1. Effect of additions of P to soils on the amounts of acid-soluble P extracted before and after cropping, and the relationship between these amounts and the uptake of P by alfalfa.

Availability of Phosphorus in Soils Pre-treated with Phosphate

The amounts of acid-soluble, adsorbed, $NaHCO_3$-soluble, and water-soluble phosphorus extracted from the pre-treated soils before and after cropping for a 2-year period are shown in Figures 1, 2, and 3. For purposes of comparison, the amounts of phosphorus removed by the crops in both years from the soils pre-treated with phosphate are included in the graphs. Regression equations (quadratic) relating rates of pre-treatments and

TABLE 3.—SLOPE OF CURVES RELATING THE PHOSPHATE PRE-TREATMENTS AND THE AMOUNTS OF PHOSPHORUS REMOVED BY THE PLANTS OR BY CHEMICAL EXTRACTION BEFORE CROPPING

(Values represent slope of tangent line to the curve $Y = a + bX + cX^2$ at different points)

Soil	P pre-treatment (p.p.m.)	Methods used to remove P from soils			
		Plants (mgm./pot)	Acid (Truog) (p.p.m.)	$NaHCO_3$ (p.p.m.)	Water (p.p.m.)
Castor (C)	22	2.16	0.391	0.343	0.016
	77	1.92	0.458	0.369	0.032
	220	1.31	0.633	0.465	0.074
Castor (O)	22	2.73	0.638	0.422	0.008
	77	2.31	0.633	0.428	0.010
	220	1.21	0.619	0.445	0.013
Castor (P)	22	2.18	0.419	0.403	0.002
	77	2.01	0.474	0.437	0.016
	220	1.57	0.619	0.524	0.053
Grenville (C)	22	1.95	0.493	0.323	0.003
	77	1.73	0.529	0.364	0.006
	220	1.13	0.625	0.471	0.014
Grenville (S)	22	2.40	0.319	0.253	0.000
	77	2.07	0.375	0.303	0.002
	220	1.20	0.524	0.433	0.009
Grenville (G)	22	2.71	0.322	0.203	0.003
	77	2.36	0.386	0.259	0.003
	220	1.43	0.554	0.408	0.005
Carp (L)	22	1.80	0.710	0.435	0.011
	77	1.66	0.730	0.481	0.015
	220	1.28	0.781	0.602	0.026
Carp (G)	22	2.18	0.609	0.340	0.011
	77	1.94	0.657	0.367	0.015
	220	1.31	0.782	0.438	0.027
Carp (B)	22	2.86	0.577	0.401	0.010
	77	2.53	0.616	0.414	0.015
	220	1.67	0.721	0.447	0.024

uptake of phosphorus, acid-soluble, $NaHCO_3$-soluble, and water-soluble phosphorus were calculated. To show the effect of increasing rates of pre-treatments on phosphorus supply in the soils, the slopes at different points on the curves were determined from the regression equations and are presented in Table 3.

The uptake of phosphorus by the plants increased with increasing rates of phosphate pre-treatments. As shown by the graphs and the appropriate values for slope in Table 3, however, the magnitude of the increase in uptake resulting from increase in rate of pre-treatment became smaller with ascending rates.

The amount of acid-soluble phosphorus extracted with the Truog procedure from the soils before seeding increased considerably with increasing rate of pre-treatment (Figure 1). For all soils, the average recovery of the added phosphate using this procedure was about 42 per cent for a rate of 44 p.p.m. (P)* and about 65 per cent for a rate of 440 p.p.m. (P). Following cropping, the values for Truog phosphorus were reduced in magnitude and the residual effect of the pre-treatments was

* A rate of 44 p.p.m. (P) is equivalent to 200 lb. P_2O_5 per acre.

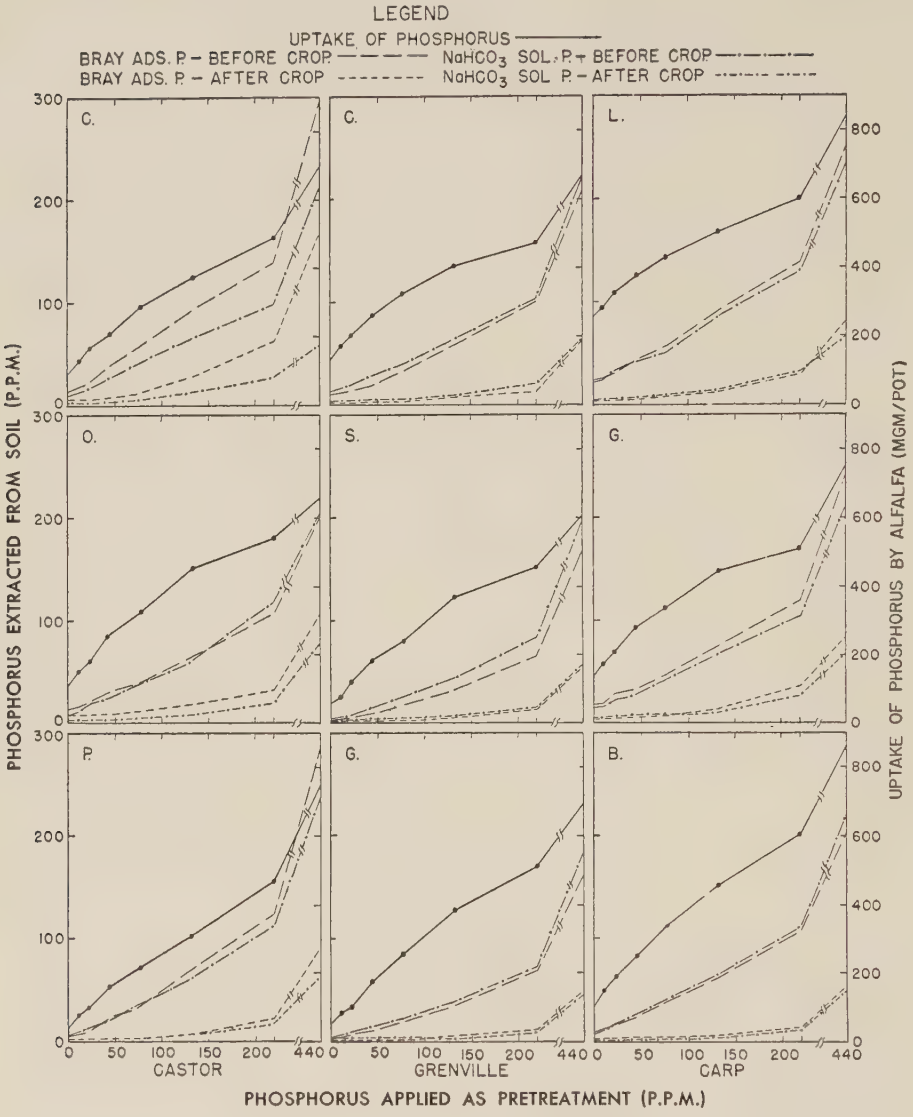

FIGURE 2. Effect of additions of P to soils on the amounts of Bray adsorbed and $NaHCO_3$-soluble P extracted before and after cropping, and the relationship between these amounts and the uptake of P by alfalfa.

relatively slight, particularly at lower rates, as compared with the results obtained before cropping. The effect of the phosphate pre-treatments on acid-soluble phosphorus as measured by the Bray method was much less pronounced than that shown for the Truog method.

Except for the C sample of Castor silt loam, the values for adsorbed and $NaHCO_3$-soluble phosphorus in the same samples were similar (Figure 2). Prior to cropping, the amounts of phosphorus determined by these methods increased markedly with increasing rates of added phosphate.

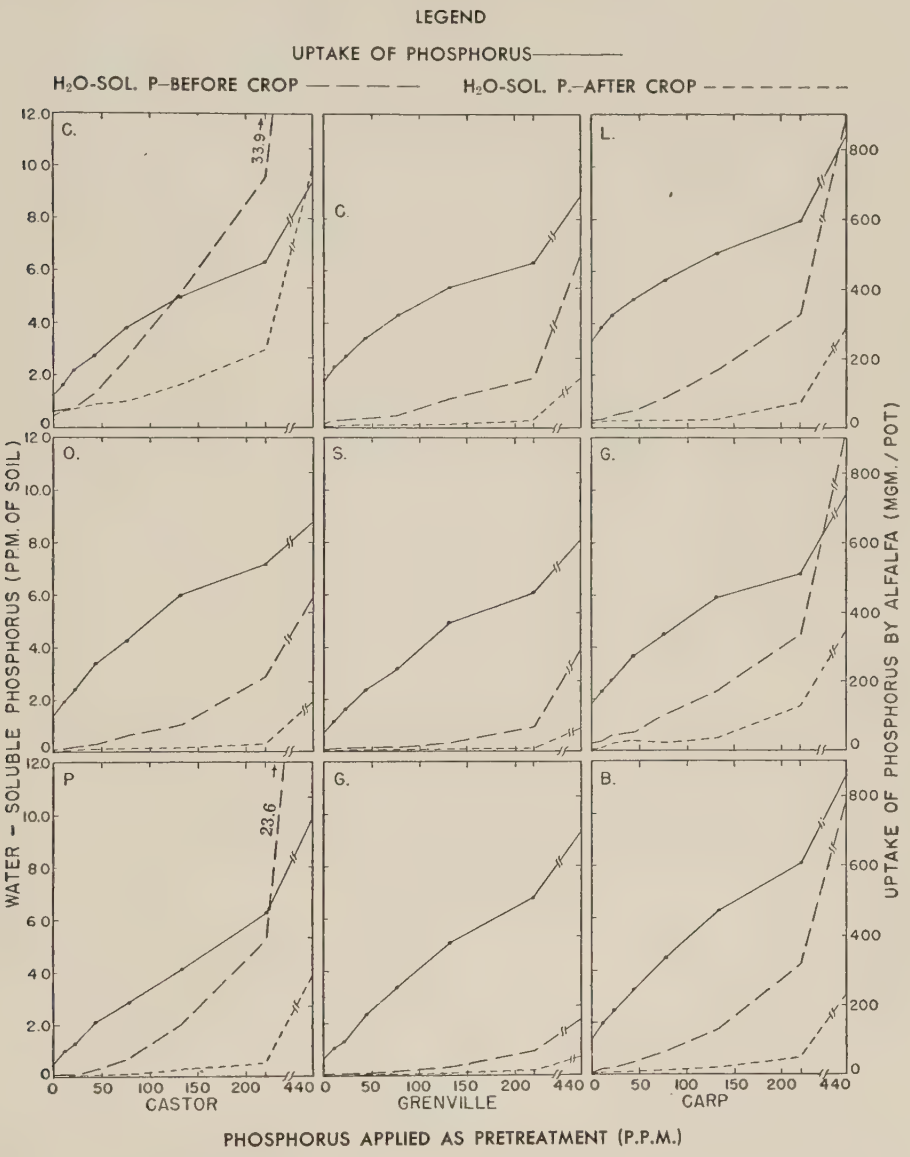

FIGURE 3. Effect of additions of P to soils on the amounts of water-soluble P extracted before and after cropping, and the relationship between these amounts and the uptake of P by alfalfa.

In terms of $NaHCO_3$-soluble phosphorus, the average recovery of phosphorus added to the soils was about 35 and 46 per cent for rates of 44 and 440 p.p.m. (P), respectively. After cropping, the trends for reduction in adsorbed and $NaHCO_3$-soluble phosphorus and for only slight residual effect of the pre-treatments at the lower rates were similar to those shown for the Truog values.

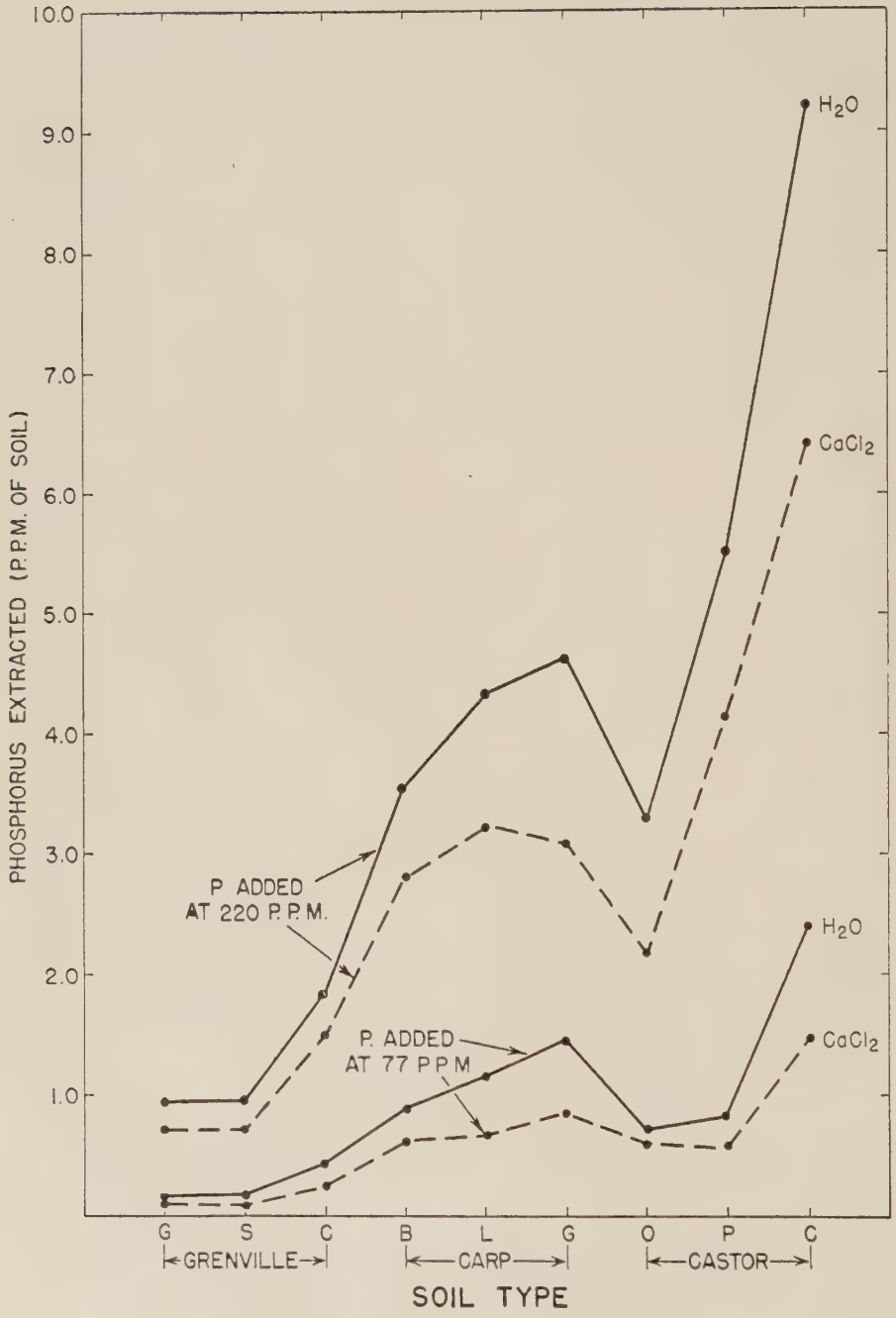

FIGURE 4. Relationship of amounts of P extracted with water and 0.01 M $CaCl_2$ from soils pre-treated with superphosphate.

As shown by Figure 3, the increase in water-soluble phosphorus with increasing rates of phosphate pre-treatments varied considerably between soils. For example, with addition of phosphate at a rate of 440 p.p.m. (P), the recovery as water-soluble phosphorus was only 0.5 per cent for the G sample of Grenville loam as compared with 7.6 per cent for the C sample of Castor silt loam. The effect of the pre-treatments on water-soluble phosphorus after cropping was much more pronounced for the latter than for the other samples.

In most instances, the values for slope of the curves (Table 3) show that the increase in the amounts of acid-soluble, $NaHCO_3$-soluble, and water-soluble phosphorus resulting from a given amount of added phosphate, became greater as the rates were increased. The different samples of Castor silt loam showed considerable variation with respect to increase in acid-soluble and water-soluble phosphorus in relation to rate of added phosphate. As shown by the values for slope at the lower rates, the increase in acid-soluble phosphorus in sample O was more pronounced than that found for the other samples of this soil. On the other hand, the increase in water-soluble phosphorus with increasing rates was much less for this sample than for the C and P samples of Castor. The pH value of 7.6 for sample O (Table 2) was higher than that obtained for any of the other samples. The values for slope show that the recovery in terms of acid-soluble and $NaHCO_3$-soluble phosphorus was greater for the C than for other samples of Grenville loam and for the L than for other samples of Carp clay loam. Without addition of phosphate, it was shown earlier (Table 2) that the amounts of soluble phosphorus in the C sample exceeded those for the other samples of Grenville loam and the amounts for the L sample exceeded those for the other samples of Carp clay loam. The slopes of the curves for acid-soluble, $NaHCO_3$-soluble, and water-soluble phosphorus show that the recovery of added phosphate tended to be greater from Carp clay loam than from Grenville loam.

In a brief review of the subject, Williams (13) refers to the variation in water-soluble phosphate in relation to electrolyte concentration, and suggests that the concentration of phosphorus in a neutral salt extract might be expected to be an important criterion of the phosphorus status of soils. Since the results for water-soluble phosphorus in the different samples of Castor silt loam varied considerably, it was of interest to compare values for water-soluble phosphorus with those obtained by extraction with 0.01 M $CaCl_2$. As shown by Figure 4, the variations in soluble phosphorus occurring between the different soil samples were similar for the water and $CaCl_2$ solution. As expected, the values for water-soluble phosphorus were higher than those obtained with the salt solution.

In the present investigation, the lack of data for the amounts of phosphorus in the alfalfa roots, as well as the possibility that the amounts of soil phosphorus released to the plants was not constant with addition of phosphate, imposed limitations on interpretation of the data in terms of the amounts of fertilizer phosphorus recovered by the plants. Nevertheless, the average amount of phosphorus removed by the top growth for a rate of 200 lb. P_2O_5 per acre exceeded that for the untreated soil by an amount equivalent to 65 per cent of that added. The corresponding

increase in the uptake of phosphorus for a rate of 2000 lb. P_2O_5 per acre over the uptake for the untreated soils was 31 per cent of that added. The amounts of phosphorus extracted from the soils after cropping (Figures 1, 2 and 3) indicated accumulation of phosphorus in the samples treated at the rate of 2000 lb. P_2O_5 per acre, but not in those treated at 200 lb. P_2O_5 per acre. Thus the decrease in the percentage recovery of fertilizer phosphorus by the plants with increasing rates was reflected in the amounts of phosphorus extracted from the soils after cropping.

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THE DETERMINATION OF FIBRE THICKNESS IN WOOL

I. A COMPARISON OF CERTAIN TECHNIQUES FOR DETERMINING AVERAGE FIBRE THICKNESS[1]

S. B. Slen and E. C. Banky

Canada Department of Agriculture, Lethbridge, Alberta

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ABSTRACT

In this study four methods (cross-section, width, count, and comparator methods) were compared to ascertain their relative accuracy for the determination of fibre thickness in wool. Twenty samples of fine (Rambouillet) and twenty of coarse (North Country Cheviot) wool were measured separately by two operators using each of the four methods.

In the fine-wool group the cross-section method resulted in significantly ($p < .01$) coarser mean fibre thickness measurements than the remaining three methods. In the coarse wool group both the cross-section and width methods yielded significantly coarser mean fibre thickness measurements.

The operator differences were not significant in the coarse-wool samples measured but were significant for the count and comparator methods in the fine-wool group.

The repeatability of the two objective methods was superior to that of the methods employing subjective estimation or comparison. There was a tendency to introduce a slight upward bias in the measurements of both fine and coarse wool owing to the possibility of oblique cutting in the cross-section method. In the width method the measurements appeared to be biased only for coarse wool as a result of the "lie effect" of the flat, kempy segments. For this reason the width method was considered to be more accurate than the cross-section method.

INTRODUCTION

Fibre thickness is the most important dimensional characteristic in determining the economic value of wool. Consequently, a number of methods have been developed, differing in accuracy and length of time to complete, for the determination of fibre thickness. Several methods have been adopted in special fields of wool research, such as the gravimetric method (11), the air-flow method (3), the photometric methods (2, 5), the interference method (4), the determination of the cross-sectional area of a 100-fibre bundle under pressure (8), and the sedimentation of fibres in a liquid medium (9). However, for practical purposes the projection methods, involving the direct measurement of the magnified fibre images, have been found more acceptable. The main advantage of the direct methods is that an estimate of the variability can be obtained.

In this laboratory a large number of samples from yearling sheep must be evaluated during the period between shearing and breeding so that the information will be available before the final selection of breeding stock is made in the fall. Consequently, it is necessary to use a rapid method of satisfactory accuracy. In view of this the suitability of four methods of determining mean fibre thickness was investigated.

MATERIALS AND METHODS

Materials

The wool used in this study was obtained by taking composite samples from skirted fleeces at shearing time. The samples were scoured in

[1] Contribution from the Division of Animal Husbandry, Experimental Farms Service, Ottawa, Canada.

accordance with standard laboratory procedure, conditioned, and then divided into 16 zones from which a composite sub-sample was drawn for the determination of average fibre thickness. The fibres were prepared for measurement according to the specifications required in each method. Twenty samples of fine (Rambouillet) and 20 of coarse (North Country Cheviot) wool were used in comparing the various methods.

Methods of Measurement

Four different methods of determining mean fibre thickness were employed, namely, the cross-section, width, count, and comparator methods. A brief description of these methods is given below.

(*a*) *The cross-section method* (1). Cross-sections of the wool fibres were prepared by using the Hardy thin cross-sectioning device and were mounted on glass slides. These sections were projected at a magnification of 500X on to a frosted glass screen. Measurements of the fibre thickness were made with a transparent millimeter scale. Two hundred and 400 measurements per sample were made on the fine and coarse wools, respectively, by each operator, using different slides.

(*b*) *Width method* (1). The wool was placed in the fibre microtome and short sections of approximately 200 microns in length were cut. These sections were mounted on a glass slide, dispersed in Canada Balsam, and projected at a magnification of 500X. To ensure random selection, a circle having a diameter of 10 cm. was drawn in the middle of the projected field and only those fibres falling within this circle were measured. In this method one operator measured fibres on the upper half of the slide and the other used the lower half. The measurements were made with a wedge scale.

(*c*) *Count method* (7). The procedure was to project the fibre cross-sections at a magnification of 500X on to a white screen and to count the number of fibres falling within a 125 sq. cm. area. At the same time the degree of fibre packing, i.e., solid, adjacent, or loose, was estimated. On the basis of these data the average fibre thickness and the standard deviation were estimated by means of specially prepared tables and graphs. For greater accuracy three determinations per sample were obtained by each operator and the data were averaged.

(*d*) *Comparator method* (12). In this method the fibre cross-sections on a representative area of the slide were compared at a magnification of 500X with those of known thickness and variability on a specially-prepared film strip. On the basis of these comparisons the average fibre thicknesses and their standard deviations were estimated. In methods (c) and (d) the same slides were used as those employed for the cross-section method.

Operator differences were determined by using the paired treatment (6) and the method differences by analysis of variance.

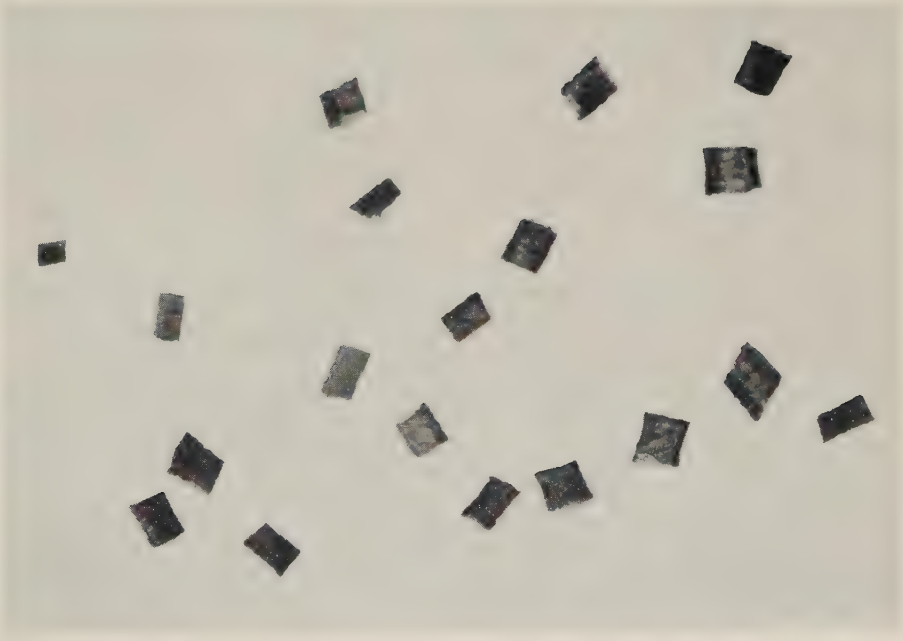

FIGURE 1. Short sections of wool fibres showing oblique cutting.

RESULTS AND DISCUSSION

The average fibre thicknesses and their respective standard deviations for the different methods by operators are shown in Table 1.

TABLE 1.—AVERAGE FIBRE THICKNESSES AS DETERMINED BY FOUR DIFFERENT METHODS

Method of Measurement	No. of Samples	Average Fibre Thickness (microns)			Standard Deviation[3]	
		Operator A	Operator B	Average	Operator A	Operator B
		Fine Wool				
Cross-Section	20	20.98	20.73	20.85[2]	3.94	3.34
Width	20	20.43	20.18	20.30	3.69	3.46
Count	20	20.28	19.95[1]	20.11	2.69	2.61
Comparator	20	19.95	20.58[1]	20.04	3.57	3.58
		Coarse Wool				
Cross-Section	20	36.55	36.15	36.35[2]	8.51	8.93
Width	20	36.22	35.84	36.03[2]	10.58	9.58
Count	20	34.92	34.90	34.91	6.37	6.32
Comparator	20	34.10	34.51	34.30	7.80	6.96

[1] Significant operator differences ($p < .05$).

[2] Significantly ($p < .01$) greater than the averages obtained by the remaining methods.

[3] The standard deviation of the measurements were calculated for each sample. These were averaged by extracting the square root of their mean square.

In the coarse-wool group there were no operator differences in average fibre thickness for any of the four methods studied. However, in the fine-wool group significant operator differences occurred in both the count and comparator methods. Since a method for fibre measurement must produce results with a high degree of repeatability it would appear that the cross-section and width methods were superior to the other two.

In measuring the fine-wool samples it was found that the use of the cross-sectional method resulted in average thickness measurements that were significantly greater than those of the other three methods. Among the coarse-wool samples both the cross-section and the width methods gave average measurements that were significantly ($p < .01$) coarser than those obtained by the other two methods.

The standard deviations shown in Table 1 indicate that all methods provided somewhat similar estimates of variability. However, relatively lower estimates of variability were obtained with the count method in both the fine and coarse wool samples.

Previous results obtained in interlaboratory tests with the U.S. Department of Agriculture* together with those of this study have indicated that the cross-sectional method results in slightly greater average measurements than the width method. It seems probable that a portion of this bias is introduced by the method of preparing the fibres for projection. The fibre bundle is placed in the oblong slot of the Hardy thin cross-sectioning device, embedded in collodion, and a section is cut along

* Pohle, E. M. Reports of the Wool Fineness Committee. U.S.D.A. Mimeo. Circ. 1950.

the length of the slot. If the fibres are mounted while improperly aligned or if any movement of the fibres in the mounting medium occurs during sectioning there will be a tendency to cut the fibres obliquely (Figure 1). Similarly, any residual crimp in the fibre may result in oblique cutting. Where the plane of cutting is not perpendicular to the fibre axis there will be a varying amount of upward bias in the fibre thickness measurements. Thus, even if extreme care is exercised, there is a possibility of obtaining somewhat greater values with the cross-sectional method.

It was noted that some of the coarse wool samples contained a certain amount of kemp. Kempy fibres in Cheviot wool are coarse, flattened structures. In a fibre bundle as used in the Hardy thin cross-sectioning device they will occupy a random position, whereas when cut to short lengths and dispersed in a liquid medium they have a tendency to lie on their flat side. A small error may have been introduced in the coarse-wool means obtained by the width method as a result of this phenomenon. Because the bias is in the same direction as the error resulting from oblique cutting in the cross-sectional method, the method differences tend to appear smaller in the coarse-wool group.

In summing up the relative merit of the methods studied, it appears that the repeatability of the two objective methods was superior to that of the methods where subjective estimation or comparison was employed. Since there was the possibility of introducing a slight upward bias in the measurements obtained by the cross-section method in both fine and coarse wool, whereas in the width method the measurements appeared to be biased only for coarse, kempy wool, the latter was considered to be more accurate than the cross-section method.

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THE DETERMINATION OF FIBRE THICKNESS IN WOOL

II. A COMPARISON OF THE WEDGE AND MICRON SCALES FOR MEASURING FIBRE THICKNESS[1]

S. B. Slen and E. C. Banky

Canada Department of Agriculture, Lethbridge, Alberta

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ABSTRACT

In this study the relative merits of the wedge scale and an improved micron scale were compared for use in the width method of measuring wool-fibre thickness. Twenty fine-wool samples were measured by four different operators using both the wedge and micron scales. A significant, though small (0.25 micron), difference occurred in the fibre thickness means obtained by the two different scales with those pertaining to the wedge scale being coarser. A theoretical discussion is given on the possible sources of error connected with the use of the wedge scale and it is concluded that this bias may result from the design of the wedges.

A time study revealed that more than twice as much time was required to complete the measurements and the pertaining calculations using the wedge scale as compared to the micron scale.

INTRODUCTION

In a previous paper Slen and Banky (3) reported the results of a study in which four methods of determining average fibre thickness in wool were compared. It was found that the greatest accuracy pertained to the width method. In this method fibre sections approximately 200 microns in length were cut and dispersed on the slide in a liquid medium and the apparent thicknesses of these sections measured with a convenient scale. In the tentative method approved by the American Society for Testing Materials (1) the measurements are made with a wedge scale. The main advantage of this scale is that the recording of the measurement data is done on the scale itself and this eliminates the need for a second operator. On the other hand, the wedge scale appears to incorporate several disadvantages. It is somewhat inconvenient to handle, especially on coarse wool samples, where measurements must be made on both sides of the scale. It cannot be used satisfactorily on fibre images where the edges focus differentially. The problem concerning the portion of the cuticular scale edges to be included in the measurements is a matter of personal opinion and a possible source of error. However, the most serious criticism of the wedge (and this evidently applies to most diameter and bidiameter scales in use) is that the measurements are done by fitting two almost parallel lines, both possessing width of their own, to the outer edges of the fibre image. The implications of this feature of the wedge scale on the accuracy of the measurements will be discussed later. It should be pointed out that the wedge scale may be the source of a slight upward bias in the measurements. In order to overcome these possible sources of error and the relative slowness associated with the wedge, an effort was made to devise a more efficient measuring scale. As a result, a simple micron scale, similar to those employed in the Zeiss-Lanameter,

[1] Contribution from the Division of Animal Husbandry, Experimental Farms Service, Ottawa.

was designed. In preliminary trials this micron scale appeared to be more convenient than the wedge, and consequently a study was conducted to compare their relative accuracies and speeds. This paper reports the results of this study.

MATERIALS AND METHODS

Twenty, fine wool (Rambouillet), composite sub-samples were drawn according to the procedure described in Part I of this study (3), to be used for the measurements. The fibres were cut in the Hardy microtome and slides prepared as outlined in the tentative method of test for fineness of wool (1). Two hundred fibres per sample were measured by four different operators using both the micron and wedge scales. The wedge scales used were the standard design required by the A.S.T.M. (1). The micron scale was designed in this Laboratory featuring theoretically dimensionless (triangular) graduations on a transparent photographic film (Figure 1). When measuring, the scale was manipulated with one hand and the other was used to record the measurement data. All slides were marked to ensure that essentially the same fibres were measured by each operator in both methods. Standard forms were used to record the data and to compute means and standard deviations. In addition, a record was maintained of the time used for the measurements and for the calculations.

Operator and method differences were evaluated by the paired treatment described by Goulden (2).

RESULTS AND DISCUSSION

The average fibre thicknesses and their corresponding standard deviations as measured by the wedge and micron scales by four operators are listed in Table 1.

TABLE 1.—AVERAGE FIBRE THICKNESSES AND STANDARD DEVIATIONS OF WOOL SAMPLES MEASURED WITH THE WEDGE AND MICRON SCALES

Operator	Average thickness (microns)		Standard deviation[5] (microns)	
	Wedge scale	Micron scale	Wedge scale	Micron scale
A	23.58	23.55	4.08	4.06
B	24.20[1, 2]	23.90[2]	4.28	4.20
C	23.78[1]	23.40	4.14	4.18
D	23.44[1, 4]	23.17[3]	3.92	4.02
Average	23.75	23.50	4.09	4.13

[1] Significant method differences ($p < .01$).

[2] Significantly greater than the averages obtained by the remaining operators ($p < .01$).

[3] Significantly smaller than the averages obtained by operators A, B ($p < .01$).

[4] Significantly smaller than the averages obtained by operators B, C ($p < .01$).

[5] The standard deviation of the measurements was calculated for each sample. These were averaged by extracting the square root of their mean square.

FIGURE 1. Micron scale.

The differences between methods, ranging from 0.03 to 0.38 micron, were significant for operators B, C, and D. It will be noted that, regardless of the magnitude of difference, in each case the average measurements obtained with the wedge scale were coarser than those obtained with the micron scale.

In the introduction it was pointed out that in the wedge method the fibre image was fitted between two lines of measurable width. A microscopic examination of the wedge scales used for this study revealed that each of the lines was about 0.1 mm in width and that the cell values referred to the distance from centre to centre of these lines. Since the fibre image is projected on the wedge at a magnification of 500X, 0.2 microns on the fibre is equivalent to 0.1 mm. on the wedge. Consequently, there is a range of 0.4 microns within which an equally satisfactory fit is possible. The procedure in measuring the fibre is to adjust the position of the scale until the image of the fibre is projected between the boundaries of the wedge. However, when measuring there is a tendency to fit the outline of the fibre image to the inner edges of the lines on the wedge scale since the first satisfactory fit is obtained here. As pointed out earlier the distances refer to the centre of the lines and thus the fibres will be measured 0.2 microns coarser, resulting in an upward bias.

It is interesting to note that the average difference between methods was 0.25 micron which is in very close agreement with the theoretical bias resulting from the design of the wedge scales employed in this study.

In order to obtain a measure of the error connected with the wedge and micron scale methods, respectively, the operator variances were pooled for the 20 samples according to the method described by Snedecor (4). The pooled variances (s^2) for the two methods are as follows:

Method	s^2
Micron scale	.1855
Wedge scale	.1947

The relative accuracies of the measurements compared favourably with only a slight, non-significant advantage in favour of the micron scale.

The fact having been established that the accuracy of the micron scale was comparable to the wedge, it became essential that a time study of the two methods be undertaken. The time required to measure, record, and calculate the average fibre thickness is most important when it is necessary to provide such data for a large number of individual samples in a limited period of time. The results of this study are shown in Table 2.

The time study on the relative speeds of the wedge and micron scale methods revealed that more than twice as much time was required to obtain the average fibre thickness with the wedge.

TABLE 2.—AVERAGE LENGTH OF TIME REQUIRED FOR DETERMINING FIBRE THICKNESS WHEN MEASUREMENTS WERE MADE WITH THE WEDGE AND MICRON SCALES

Operator	Wedge scale			Micron scale		
	For measuring	For calculating	Total	For measuring	For calculating	Total
	min.	min.	min.	min.	min.	min.
A	37.8	8.9	46.7	17.1	3.0	20.1
B	36.2	9.4	45.6	19.4	4.0	23.4
C	40.4	11.7	52.1	23.5	3.2	26.7
D	33.8	7.0	40.8	17.4	2.7	20.1
Average	37.1	9.2	46.3	19.4	3.2	22.6

In view of the results of this study on the two types of scales it is evident that the micron scale compared favourably in accuracy with the wedge and was considerably more rapid.

ACKNOWLEDGEMENT

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VARIATIONS IN PERCENTAGE PHOSPHORUS AND PROTEIN CONTENT OF WHEAT, AS INDUCED BY FERTILIZER TREATMENT, SOIL TYPE, AND SEASON[1]

D. A. RENNIE[2]

University of Saskatchewan, Saskatoon, Sask.

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ABSTRACT

The data obtained from some 30 radiophosphorus field experiments on wheat were examined with a view to ascertaining the effects of nitrogen and phosphorus fertilization on percentage phosphorus in the grain and straw, and protein content of the grain.

The percentage phosphorus in the grain was significantly reduced as nitrogen applications were increased while phosphorus fertilization had no effect. Grain grown on stubble land contained consistently higher percentages of phosphorus than that on fallow due conceivably to a deficiency of available nitrogen in the stubble land. In general, the effect of soil type or climate caused greater variations in percentage phosphorus in the grain than fertilizer treatments. No statistical relationship existed between grain yield and percentage phosphorus. It is suggested that variations in available nitrogen in the soil may be responsible for variations in phosphorus percentage in the grain, both between soil type and on the same soils in different seasons.

The percentage phosphorus in wheat forage varied greatly with stage of growth, being initially high in early stages and decreasing to a minimal value at the soft dough stage. Phosphorus fertilization increased the phosphorus content of the forage only in early stages of growth.

Protein content of the grain was unaffected by nitrogen or phosphorus fertilization but varied greatly as a result of soil or climatic conditions.

The effect of phosphorus fertilizers on the composition of grain crops is a somewhat controversial matter, perhaps because factors other than fertilizers, such as climate and soil type (3), exert a rather marked effect. Larson *et al.* (12) found that applications of superphosphates equivalent to 30 lb. P_2O_5 per acre significantly increased the percentage phosphorus in oats. Other workers (11, 18) reported similar effects. On the other hand, Baker and Vandecaveye (3) also using oats, and Bennett (4) working with corn, reported that the grain analysis was unaffected by phosphorus fertilization. Chubb and Atkinson (8), while attempting to assess the value of plant tissue testing in diagnosing soil fertility problems, found that the phosphorus content of the leaves of oats was not altered by phosphorus fertilizer applications. Even with forage crops, where it is generally assumed that phosphorus fertilization causes a marked increase in percentage phosphorus, Mather (14) has shown that applications of triple superphosphate (T.S.P.) of the order of 1,000 lb. per acre were necessary to achieve this result, while maximum yields were obtained with a 200 lb. per acre application.

Nitrogen fertilization, either in combination with phosphorus applications or alone, has consistently resulted in a decrease in the phosphorus content of the grain (23, 18, 16, 31, 10, 3). Rossiter (22) has perhaps

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[2] Assistant Professor of Soil Science.

illustrated this effect to an abnormal degree where he reports a decrease in the percentage phosphorus of oat leaves from 4.32 to 0.37 due to an application of 4 cwt. of $NaNO_3$ per acre.

The data reported in this study were obtained from some 30 radiophosphorus field experiments on wheat conducted over a period of five years. These were examined with a view to ascertaining the effect of phosphorus and nitrogen fertilizer treatments on percentage phosphorus in the grain and straw, and on protein content of the grain. Since the plots were laid down under varying climatic and soil conditions and over a period of several years, the data afford an opportunity of assessing the effect of differing environmental conditions on these variables.

MATERIALS AND METHODS

The experimental plot sites were situated in the Brown, Dark Brown, Black and Grey Wooded Soil Zones. Full descriptions of these zonal soils have been published (17). In most instances, continuity was maintained from year to year by relocating plot sites on the same soil type for at least two consecutive years. The chemical characteristics of soil samples taken in the vicinity of each plot site have been given by Rennie and Mitchell (21).

All field plots with nine treatments or less were arranged in a randomized block design while a lattice design was utilized for those with a greater number. Each treatment consisted of three rows, all given the same fertilizer application, the centre or radioactive row only being harvested. Six replicates were used in all instances.

The $NH_4H_2PO_4$ (equivalent to 11-48-0 commercial fertilizer) and $Ca(H_2PO_4)_2$ (triple superphosphate) were used as phosphorus carriers. In certain treatments, the nitrogen content of the phosphorus carriers was increased by adding the required amount of NH_4NO_3. The fertilizers and the grain (Thatcher wheat) were sown together, using a small plot power seeder.

TABLE 1.—EFFECT OF FERTILIZER TREATMENT ON THE PERCENTAGE PHOSPHORUS IN THE GRAIN AND STRAW

(Average of 8 plot locations, and for the years 1951 and 1952)

Fertilizer treatment*	Mg. P per 100 g.			Yield of grain bu./acre	
	1951	1952		1951	1952
	(grain)	(grain)	(straw)		
Check	352	375	52	33	32
$NH_4H_2PO_4$	354	368	50	40	39
$Ca(_2PO_4)_2$	352	371	51	38	37
$Ca(H_2PO_4)_2$ plus 5.5 lb. N/ac. as NH_4NO_3	357	372	50	38	37
L.S.D. (P = .05)	N.S.	N.S.	N.S.	3.2	2.4

*All phosphorus carriers were applied at 24 lb. P_2O_5 per acre.

For total analysis, the grain and straw samples were ground and wet ashed by the method of Brenner and Harris (6) and total phosphorus determined by the phosphomolybdate blue reaction (24) or the metavanadate method (11). Nitrogen was determined on a semi-micro basis using a distillation apparatus similar to that described by Markham (13).

RESULTS AND DISCUSSION

Effect of N and P Fertilizers on Percentage Phosphorus in Grain and Straw

Phosphorus Fertilizers: The data given in Tables 1, 2 and 3 inclusive illustrate that phosphorus fertilization, under the soil and climatic conditions prevailing in the vicinity of the plots, has not significantly altered the percentage phosphorus either in the grain or in the straw.

Table 1 represents the average effects of $NH_4H_2PO_4$, $Ca(H_2PO_4)_2$, and $Ca(H_2PO_4)_2$ to which sufficient nitrogen was added as NH_4NO_3 to make this treatment equivalent in N and P to that of $NH_4H_2PO_4$. The individual plot data (from the eight plot locations given in Table 4) were averaged to determine the effect of the treatments on the phosphorus content of the grain. In spite of rather large yield increases, no significant variations in the phosphorus content of either grain or straw occurred.

The data obtained in 1952 from four plot locations in the Black Soil Zone were averaged and are listed in Table 2. Again it is apparent that, where no nitrogen was present in the phosphorus carrier, as is the case with the $Ca(H_2PO_4)_2$ treatment, the phosphorus content of the grain or straw was not significantly altered.

TABLE 2.—EFFECT OF FERTILIZER TREATMENT ON THE PERCENTAGE PHOSPHORUS IN THE GRAIN AND STRAW

(Average of 4 plot locations in the Black Soil Zone, 1952)

Fertilizer treatments			Mg. P./100 g.		Yield of grain bu./acre
Lb. per acre		Phosphorus carrier	Grain	Straw	
*N	P_2O_5				
0	0	—	407	70	32.4
5.5	24	$NH_4H_2PO_4$	386	67	38.3
30.0	24	$NH_4H_2PO_4$	378	63	38.5
**30.0	24	$NH_4H_2PO_4$	392	67	36.7
0	24	$Ca(H_2PO_4)_2$	398	69	36.0
5.5	24	$Ca(H_2PO_4)_2$	393	66	35.8
30.0	24	$Ca(H_2PO_4)_2$	378	59	38.4
**30.0	24	$Ca(H_2PO_4)_2$	407	76	37.4
L.S.D. (P = .05)			10	9	3.7

* NH_4NO_3 was used as N source to increase the nitrogen content of the phosphorus carrier up to the specified amount.

**N broadcast at the four-leaf stage.

The data obtained in 1953 (Table 3) substantiate the findings of the previous two years, as it is evident that increasing rates of phosphorus fertilization at any one level of nitrogen application generally have not altered the phosphorus content of the grain on either fallow or stubble land. There are two exceptions to this observation which should be noted. First, where $NH_4H_2PO_4$ was applied alone, it is apparent that a significant decrease in percentage phosphorus has occurred as the rate of P application was increased. This is evident in both fallow and stubble plot data and can be attributed to the increasing rate of application of nitrogen that was applied in the $NH_4H_2PO_4$ form. Second, in the stubble plot data where $Ca(H_2PO_4)_2$ was used as a source of phosphorus, some erratic differences in percentage phosphorus in the grain were recorded.

The phosphorus treatment means of the data for 1953 are given in Figure 1 for both $Ca(H_2PO_4)_2$ and $NH_4H_2PO_4$. Each treatment mean represents the average of the check, 6, 12 and 24 lb. P_2O_5 applications which were variously fertilized with nitrogen. Where $Ca(H_2PO_4)_2$ was used as the phosphorus source, all averages represent equivalent rates of nitrogen. The $NH_4H_2PO_4$ treatment means do not, however, represent equivalent rates of nitrogen as, where this carrier was applied alone (no NH_4NO_3 added), increasing rates of application would necessarily result in an unavoidable increase in nitrogen application. This additional nitrogen is reflected in the treatment means only at the 24 lb. P_2O_5 rate of application on the fallow plot where a significant decrease in the phosphorus content compared to the check is apparent. This decrease can be attributed to the additional nitrogen applied since the $Ca(H_2PO_4)_2$ has not in any instance altered the phosphorus content of the grain.

TABLE 3.—EFFECT OF N AND P FERTILIZATION ON MILLIGRAM PERCENTAGE PHOSPHORUS IN THE GRAIN FOR A FALLOW AND STUBBLE PLOT

N applied lb./acre	Rate of application of phosphorus carrier, lb. P_2O_5 per acre						
	$Ca(H_2PO_4)_2$				$NH_4H_2PO_4$		
	0	6	12	24	6	12	24
	A. *Stubble plot, Melfort silty clay, 1953*						
0	456	443	430	441	437	421	409
10	400	406	434	422	418	414	428
20	378	405	388	400	431	390	411
40	362	372	358	363	377	360	380
	B. *Fallow plot, Melfort silty clay loam, 1953*						
0	354	348	346	345	358	344	334
10	345	349	342	342	341	348	334
20	334	338	340	340	339	346	328
40	339	338	324	325	343	323	335

L.S.D. (P = .05) (A) Stubble plot = 21; (B) Fallow plot = 17

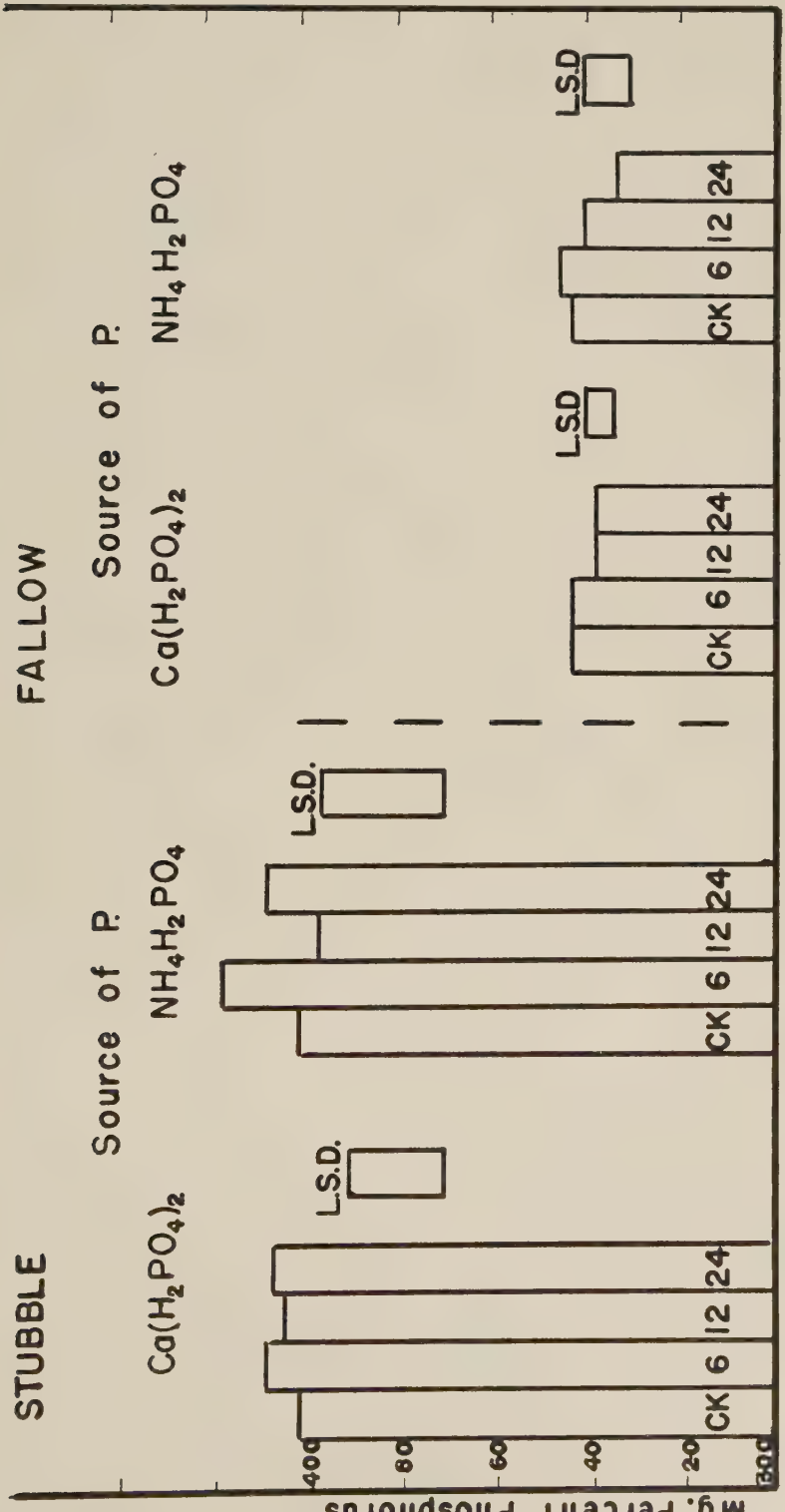

Figure 1. Effect of phosphate fertilization on the milligram percentage phosphorus in the grain for a fallow and stubble plot.

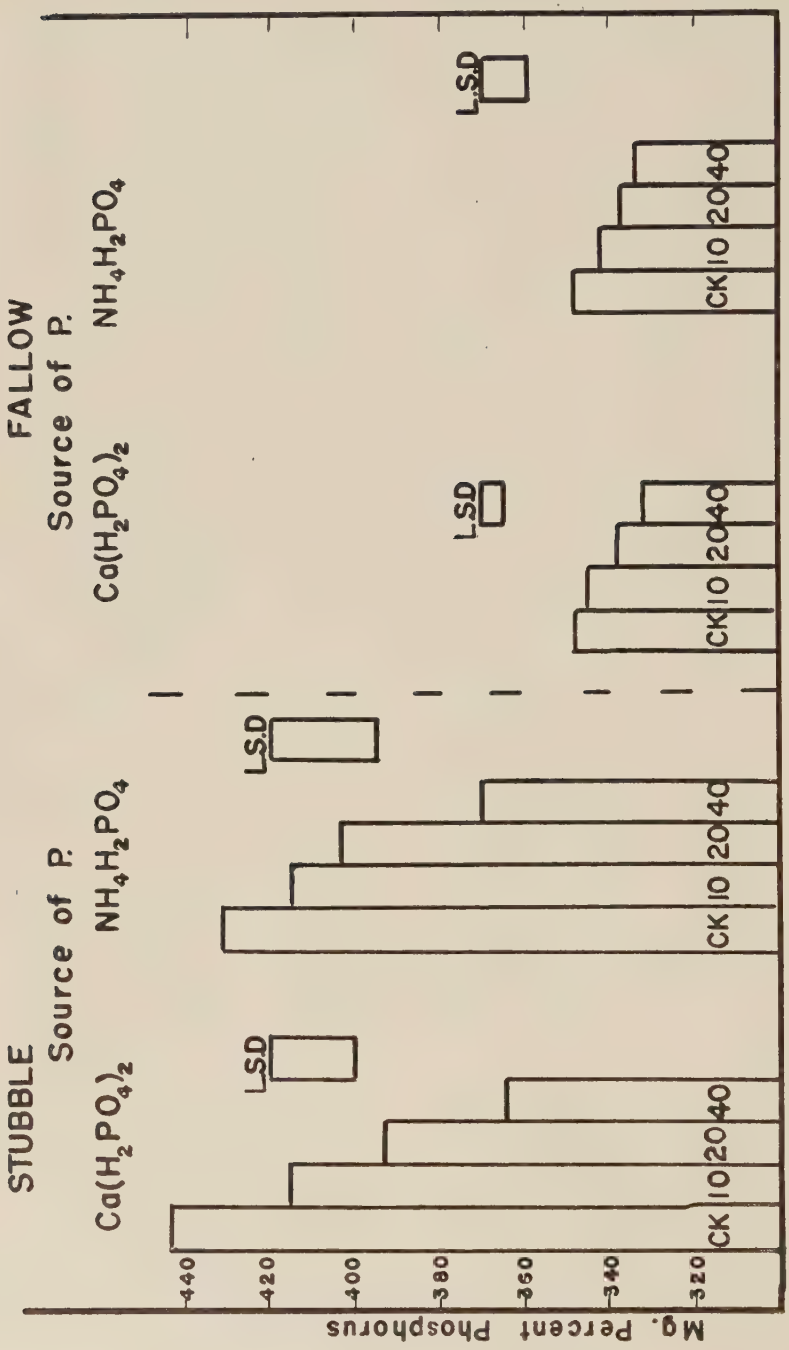

Figure 2. Effect of nitrogen fertilization on the milligram percentage phosphorus in the grain for a fallow and stubble plot.

Nitrogen Fertilizers: It is evident from the data given in Table 2 that a significant reduction in the phosphorus content of the grain or straw occurred only where nitrogen was applied together with the phosphorus. Top dressing with nitrogen at the four leaf stage was not effective in reducing the percentage phosphorus.

A more complete set of data illustrating the effects of nitrogen on the phosphorus content of the grain is afforded in Table 3. The decrease in percentage phosphorus that occurs with increasing nitrogen applications is repeatedly apparent on both the stubble and fallow plots. This trend is evident at all rates of phosphorus applications; in most instances on the stubble plot, but fewer cases on the fallow plot, the successive increments in nitrogen applications have resulted in significant reductions in the percentage phosphorus. The stepwise reduction in the phosphorus content of the grain with increasing rates of nitrogen applications is more clearly illustrated in the average data presented in Figure 2. Baker and Vandecaveye (3) reported that the drop in phosphorus content of the grain due to nitrogen could be practically overcome when phosphorus was applied with the nitrogen. While there is a tendency for such an effect on the stubble plot data where $Ca(H_2PO_4)_2$ is used as a source of phosphorus (Table 3), there is little evidence in the remainder of the data to indicate that the depression in phosphorus content of the grain due to nitrogen can be overcome with the rates of phosphorus used.

Comparison of Fallow and Stubble Crops

The average phosphorus content of the stubble grain given in Table 3 is 32 per cent greater than that found on the fallow plot. A comparison of the percentage phosphorus between fallow and stubble grain is more clearly indicated in the treatment means of the data which are graphically illustrated in Figures 1 and 2. These data are further substantiated by those of the previous year (29) where the average percentage phosphorus in the grain for the stubble plot was 0.476, while that of the adjacent fallow plot was 0.402. The percentage figures for the straw were 0.110 and 0.077, respectively.

It is evident from the comparative data obtained on the fallow and stubble grain (Table 3 and Figures 1 and 2) that the decrease in percentage phosphorus in the grain due to nitrogen fertilization is of much greater magnitude on stubble grain. In most cases, heavy nitrogen applications have reduced the percentage phosphorus in the stubble grain to values closely approximating those on fallow.

It would seem probable that the higher phosphorus content of the stubble grain may reflect the rather marked nitrogen deficiency that existed in the stubble soil. The highly significant yield responses to nitrogen on stubble land and the lack of response to nitrogen on the fallow confirm their low and high levels of nitrogen respectively. McCalla and Woodford (16) similarly explain the higher phosphorus content of grain sown on an Alberta Podzol soil as compared to that grown on a deep black soil on the basis of a nitrogen deficiency in the former. Even on soils very deficient in phosphorus, Chapman (7) found that a nitrogen deficiency caused phosphorus to accumulate in the plant.

TABLE 4.—EFFECT OF SOIL TYPE (OR CLIMATE) ON THE PERCENTAGE PHOSPHORUS IN THE GRAIN AND STRAW FOR THE YEARS 1951 AND 1952

Soil association	Mg. P per 100 g.*			Yield of grain bu./acre	
	1951	1952		1951	1952
Dark Brown zone	(grain)	(grain)	(straw)		
Regina heavy clay	293	390	51	52	37
Weyburn clay loam	400	326	30	29	30
Weyburn loam	367	330	30	39	40
Asquith fine sandy loam	442	378	42	15	37
Black zone					
Melfort silty clay	318	414	83	40	30
Melfort silty clay loam	280	406	80	35	42
Yorkton loam	348	336	42	40	33
Grey Wooded zone					
Waitville loam	383	395	51	47	43
L.S.D. (P = .05)	16	7	8	4.5	3.4

* Each value represents the average of five differing fertilizer treatments, each replicated six times.

Effect of Soil Type and Seasons on the Phosphorus Content of the Grain

The data given in Table 4 represent the average of five treatments laid down on each of the given soil associations for a 2-year period. The individual data for each location have been omitted as the phosphorus treatments used did not significantly alter the percentage phosphorus in the grain at any one site. (It is to be noted, however, that rather marked yield responses occurred at most locations due to the applied phosphorus). These findings are somewhat different from those obtained in Washington (3) where it was found that phosphorus fertilization in combination with nitrogen on the Olympic soils decreased the phosphorus content of oats while on the Felida soils an increase was observed.

The highly significant variations in phosphorus content of the grain or straw due to the soil type are considerably larger than those at any one location due to nitrogen fertilization. The milligram percentage phosphorus in the grain grown on the Dark Brown soils in 1951 (Table 4) varied from a low of 293 (Regina heavy clay) to a high of 442 (Asquith fine sandy loam). This high variation in phosphorus content within any one soil zone precludes any definite conclusion that may be drawn concerning a typical zonal phosphorus content of grain. Furthermore, in 1951, the grain grown on the four Dark Brown soils contained an average milligram percentage phosphorus of 376, while the average of the three Black soils

was only 315. The reverse occurred in 1952, the average for the Black soils being 385 as compared with 356 for the Dark Brown. Thus, the conclusions reached by Newton (18) that grain grown on Alberta's Black soils tends to be lower in phosphorus than grain from other zones is not borne out. In fact, a direct comparison of soils of similar texture in the Black and Dark Brown Zone shows that, in most instances, the grain grown on the Black soil contains a higher percentage phosphorus than that grown on its counterpart in the Dark Brown Zone.

The seasonal variations in percentage phosphorus, illustrated in Table 4 for 1951 and 1952, are further exemplified in the data presented in Table 5. The latter figures represent the milligram percentage phosphorus of the unfertilized grain grown for four consecutive years and at four locations. The highly variable influence of seasons is again quite evident. And again, it is evident that grain grown on the Black Melfort soils consistently contains more phosphorus than that grown on the Dark Brown Regina soils.

Yield of Grain and Percentage Phosphorus

A comparison of yield with the phosphorus content of the grain is afforded in Tables 1, 2, 4 and 5. There is obviously no relationship between yield and phosphorus content in the data given in Tables 1 and 2 since the yield responses due to the fertilizer treatments were not accompanied by a corresponding increase or decrease in percentage phosphorus in the grain. On the Grey Wooded soils of Alberta, McAllister (15) found that the effect of different phosphorus carriers on the phosphorus content of wheat, oats and barley was generally related to yield in that large yield responses were accompanied by a decreased phosphorus content in the grain while increases in percentage phosphorus occurred where yield increases were small or lacking. This interaction of yield responses and phosphorus percentage in the grain is not evident in these data.

The yield-data in Tables 4 and 5, however, do appear in certain instances to correlate with the phosphorus content. In 1951 (Table 4) the highest

TABLE 5.—SEASONAL VARIATION IN THE PERCENTAGE PHOSPHORUS IN THE GRAIN

Soil association	Mg. P/100 g. grain*				Yield, bu./acre			
	1950	1951	1952	1953	1950	1951	1952	1953
Black Soil zone								
Melfort silty clay loam	440	310	418	353	23	24	34	42
Yorkton loam	350	340	354	—	25	37	30	—
Melfort silty clay	377	323	408	340	43	33	26	45
Dark Brown Soil zone								
Regina heavy clay	—	286	398	242	—	51	30	37

* Represents the average of six replicates for the unfertilized treatment

phosphorus content, 442 mg. per 100 grams of grain, is associated with the lowest recorded yield, 15 bushels per acre, while the highest yielding crop contained only 293 milligrams phosphorus per 100 grams of grain. A correlation analysis of the data in Table 4, as well as that in Table 5, indicated, however, that while negative correlations of 0.4392 and 0.4204 were obtained for each table respectively, in neither case were they significant. It must be concluded, therefore, that in these data no statistically significant relationship between yield and percentage phosphorus exists.

Stage of Growth and the Phosphorus Content of the Forage

It has been shown that the chemical composition of small grain forage may be considerably influenced by the amount of available plant nutrients in the soil. Direct correlations between phosphorus fertilization and the phosphorus content of oat forage have been reported from Georgia (9), and of oat (25) and wheat (26) forage from Texas.

The effect of stage of growth and phosphorus fertilization on the percentage phosphorus in wheat forage is shown in Table 6. The data were obtained on three soil types during the years 1948, 1949, 1951 and 1953. The percentage phosphorus in the fertilized crop is significantly higher than the checks only during early stages of growth. In general, after the crop has reached the shot blade stage, the phosphorus contents of the unfertilized and fertilized crops are statistically identical. Since, in the early stages of growth, the fertilized wheat plant obtains a major portion of the phosphorus from the fertilizer (27), the initial higher phosphorus content in the fertilized crop is to be expected. At later stages of growth, by far the larger amount of plant phosphorus is derived from the soil, this amount being sufficient to equalize the phosphorus contents of the fertilized and unfertilized crops.

TABLE 6.—EFFECT OF TIME OF HARVESTING ON THE MILLIGRAM PERCENTAGE PHOSPHORUS IN FERTILIZED AND UNFERTILIZED WHEAT FORAGE

Fertilizer treatments	Time of harvest							
	4-leaf	Shot blade	Soft dough	Ripe	4-leaf	Shot blade	Soft dough	Ripe
	Melfort silty clay loam, 1948				*Melfort silty clay loam, 1949*			
Control	250	250	160	170	180	220	140	140
*24 lb. P_2O_5/ac.	300	280	190	180	280	230	140	140
L.S.D. (P = .05)	18	35	N.S.	N.S.	20	N.S.	N.S.	N.S.
	Melfort silty clay, 1953				*Sceptre heavy clay, 1951*			
Control	297	218	210		162	235	143	
*24 lb. P_2O_5/ac.	323	202	215		165	331	122	
L.S.D. (P = .05)	15	N.S.	N.S.		N.S.	12	N.S.	

* $NH_4H_2PO_4$ used as phosphorus carrier

Effect of Treatment, Soil Type and Seasons on the Protein Content of the Grain

Selected grain samples were taken from the 1952 and 1953 field plot experiments for protein analyses. The analyses, presented in Table 7, illustrate the inability of phosphorus or nitrogen fertilization to alter the protein content of the harvested grain. The uniformity of protein content on any one soil type for all fertilizer treatments is rather surprising in view of the rather marked yield responses that occurred due to fertilization. The data are substantiated by the 1954 protein analyses given in Table 8. Nitrogen, even when added at the rate of 192 lb. N per acre, had no effect on the protein content of the grain. While some investigators have reported a similar lack of effectiveness of either nitrogen or phosphorus fertilization on the protein content of the grain (28, 20), others have indicated very marked and statistically significant differences in protein content due to various fertilizer treatments (2, 18). In the latter reports, nitrogen increased but phosphorus decreased the protein content of the grain.

The rather marked variations in protein content that occurred on different soils, and on the same soils in different years (Table 7), suggest

TABLE 7.—PERCENTAGE PROTEIN** IN THE GRAIN AS AFFECTED BY FERTILIZER TREATMENT AND LOCATION. THE PROTEIN CONTENT WAS DETERMINED ON GRAIN SAMPLES SELECTED FROM GRAIN GROWN ON THREE SOIL TYPES IN 1952 AND 1953 RESPECTIVELY

1952

*Fertilizer treatments lb. per acre		Weyburn loam		Melfort silty clay loam		Yorkton loam	
N	P_2O_5	Protein %	Yield bu./acre	Protein %	Yield bu./acre	Protein %	Yield bu./acre
0	0	12.5	32	16.9	34	15.0	30
5.5	24	12.4	44	17.0	45	15.0	36
30.0	24	—		17.1	45	15.6	34
L.S.D. (P = .05)		N.S.		N.S.		N.S.	

1953

		Regina heavy clay		Melfort silty clay loam		Melfort silty clay	
0	0	13.9	36	14.8	42	11.4	20
5.5	24	13.5	47	14.7	56	11.3	28
40.0	24			15.1	53	11.7	35
40.0	0			15.2	46	11.6	26
L.S.D. (P = .05)		N.S.		N.S.		N.S.	

* $NH_4H_2PO_4$ used as phosphorus source, NH_4NO_3 as additional source of nitrogen

** Per cent protein = % N x 5.7; calculated on an air-dry basis

TABLE 8.—PERCENTAGE PROTEIN** IN THE GRAIN AS AFFECTED BY FERTILIZER TREATMENTS

Soil type—Melfort silty clay loam, 1954

*Fertilizer carrier	Rate of application, lb. P_2O_5/acre.				
	0	12	24	48	96
11-48-0	15.6	15.7	15.5	15.3	15.3
17-34-0		15.4	15.4	15.1	15.0
23-23-0		15.6	15.3	15.1	15.0
27-13.5-0		15.2	15.2	15.0	15.0
29-9.7-0		15.2	14.9	15.0	——
30-7.5-0		15.4	15.3	15.0	——
33.5-0-0 (50 lb. N/ac.)	15.6				
33.5-0-0 (100 lb.N/ac.)	15.5				
L.S.D. (P = .05)	0.30				

* The fertilizers used include 11-48-0 ($NH_4H_2PO_4$) and 33.5-0-0 (NH_4NO_3) and various mixtures of these.
** Per cent protein = % N x 5.7; calculated on an air dry basis.

that factors other than the level of available phosphorus and nitrogen in the soil are responsible for the varying level of protein in cereal grains. The general association of high protein grain in areas of low rainfall efficiency is clearly indicated in the protein surveys made by the Board of Grain Commissioners of Canada (5).

SUMMARY

The highly significant reductions in the phosphorus content of the grain due to nitrogen fertilization, coupled with the ineffectiveness of the applied phosphorus, suggest that the level of available nitrogen in the soil may be partially responsible for the variations in phosphorus percentage, not only between various soils but also on the same soils in different years. This conclusion is substantiated by the fact that grain grown on soils very deficient in available nitrogen, e.g. stubble land, contained consistently higher amounts of phosphorus than that grown on fallow. In addition, since environmental conditions in the more arid regions of Saskatchewan are more conducive to both free nitrogen fixation and biological release of organic nitrogen (30), the Brown and Dark Brown soils should be expected to contain greater amounts of available nitrogen than their counterparts in the Black and Grey Wooded Soil Zones. While this has not been confirmed by actual soil testing, it appears quite plausible and would explain the lower phosphorus content of grain grown in the more arid soils as compared to that grown on related soil associations in the Black Soil Zone.

ACKNOWLEDGEMENTS

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A MINIATURE FORAGE CROP HARVESTER[1]

J. G. Kemp[2] and W. J. Pigden[3]

Canada Department of Agriculture, Ottawa

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ABSTRACT

A miniature harvester, consisting of a 30-inch rotary mower assembly attached to a 5-horsepower Gravely garden tractor, is described. In one operation, it cuts, chops, and delivers the chopped forage material into a burlap bag. It has an operating capacity of about 400 lb. of green material per hour when cutting in a 12-inch-high forage crop, yielding approximately 4 tons of green material per acre.

INTRODUCTION

Estimating the intake and digestibility of herbage consumed by grazing animals requires extensive preliminary studies with animals maintained in digestibility cages. Such investigations may require daily harvesting of moderate quantities of forage. Accordingly, a simple and inexpensive machine which would combine the cutting and chopping operations would reduce labour and equipment costs and be very convenient for such feeding trials. It would also find useful applications for small-scale grass silage and mechanical grazing investigations.

DESCRIPTION OF THE HARVESTER

The basic unit of the harvester is a 5-horsepower Gravely garden tractor, equipped with gear reduction wheels and a 30-inch four-bladed rotary mower attachment. A delivery duct was fitted to the side of the housing of the mower to direct the chopped material into a burlap bag. The complete unit is illustrated in Figure 1.

The four-bladed rotating cutter, which operates at a speed of 1200 r.p.m. at no load, was converted to a combination cutter and blower by welding a 5 × 2½-inch steel fin to the top of each blade. These fins provided the air blast for lifting the chopped material into the burlap bag. The cutter-blower assembly and its housing is illustrated in Figure 2.

The original two-piece skirt supplied with the rotary assembly was discarded and was replaced by a one-piece skirt 4½ inches in depth. To the bottom of this skirt was welded a ring which projected 1½ inches inward at right angles to the skirt and served to confine the air stream carrying the cut material. A portion of this ring was subsequently removed (see Figure 2) as it was found that this modification resulted in a cleaner cut on the right hand side of the swath. The blades were adjusted to run about one-half inch above the bottom of the skirt.

A rectangular exit for cut material was constructed on the left side of the mower housing, tangential to the circumference of the skirt. To this was fastened the 4 × 4½-inch galvanized sheet metal delivery duct. The

[1] Joint contribution from Divisions of Animal Husbandry and Field Husbandry, Soils and Agricultural Engineering, Experimental Farms Service.

[2] Agricultural Engineer, Field Husbandry, Soils and Agricultural Engineering Division.

[3] Agricultural Research Officer (Pastures), Animal Husbandry Division.

delivery end of the duct was given a wide sweeping bend with the bottom and sides cut away and was braced by an angle iron bolted across the tractor handles. A clean-out door was placed in the side of the bottom elbow. Two metal rods welded to the angle iron brace provided a support for a burlap bag in a horizontal position.

The skids and mounting pieces from the original skirts were fitted to the new skirt. One and three-quarter inch extension spacers were fastened between the skids and mounting pieces by using longer bolts to increase the height of the cutter assembly from the ground in order to supply adequate air intake to the blower. Additional air intake was provided by cutting three 3-inch circular holes in the top casing. These holes also decreased the ground suction of the blower and thus reduced the amount of loose trash and dirt picked up by the machine. Flat-iron strips were added in front of the skids to act as dividers and to prevent the collection of material at these points.

The original wheel assemblies were replaced with 4.00 × 12.00 tires on 3-to-1 gear reduction wheels (see Figure 1). This reduced the lowest forward speed from 3 to 1 m.p.h., which enabled the tractor horsepower to satisfactorily handle the operations of both cutting and blowing. The axle housing was rotated one bolt hole on the differential housing, which prevented the machine from being raised and tilted forward by the new wheel assemblies. This adjustment was possible because the reduction wheels were attached off-centre to the axle housing.

The current cost of the rotary mower attachment, gear drive and gear reduction wheels to convert a standard Gravely tractor is approximately $200. Cost of other materials and labour is estimated at $25-$50.

FIELD PERFORMANCE

The capacity of the unit to harvest forage varied a great deal with height and density of growth. Generally speaking, it had an operating capacity of 400 lb. of green material per hour when cutting in a 12-inch-high forage crop yielding approximately 4 tons of green material per acre. The material was chopped into lengths ranging from 0.5 to 2.5 inches and somewhat shredded.

While the machine made a clean cut of forages up to about 12 inches in height, it did not cut taller crops cleanly on the right-hand side, because on this side the blades were rotating in the same direction as the plants were bent by the mower housing. However, by re-cutting the same swath in the opposite direction a fairly clean cut was obtained.

Blockage of the delivery duct seldom occurred, even when cutting a heavy growth, unless the material was either exceedingly wet or the exit-end of the delivery duct became blocked by a build-up of the cut material in the centre of the bag. Care was necessary to keep the delivery-end of the duct clear.

The machine was used over a 90-day period at the Central Experimental Farm during 1954 to supply fresh forage material to sheep maintained in digestibility cages. One man harvested and prepared the forage for feeding and sampling in one operation.

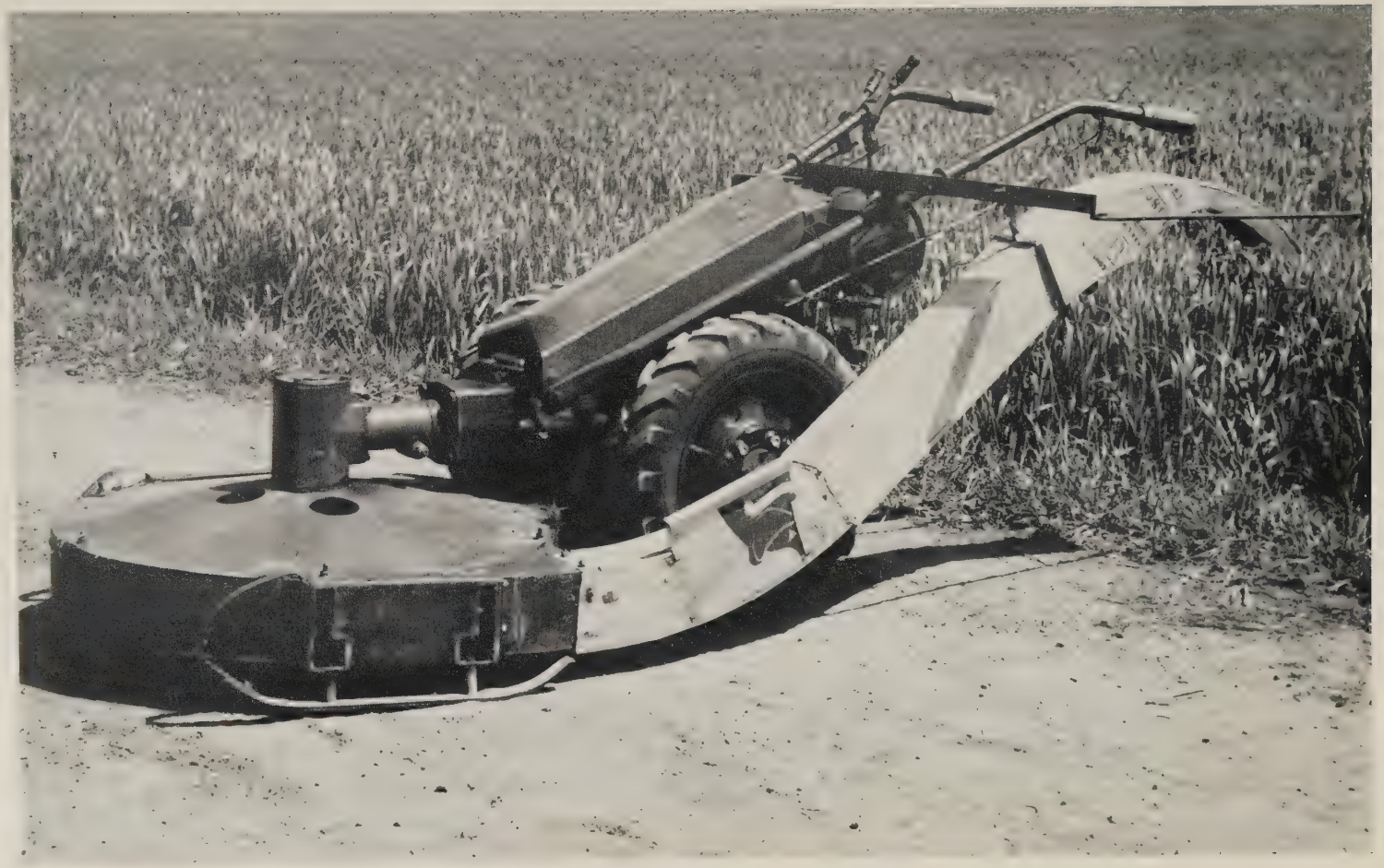


FIGURE 1. General view of harvester showing the conveyor duct and arrangement for attaching the collecting bag.

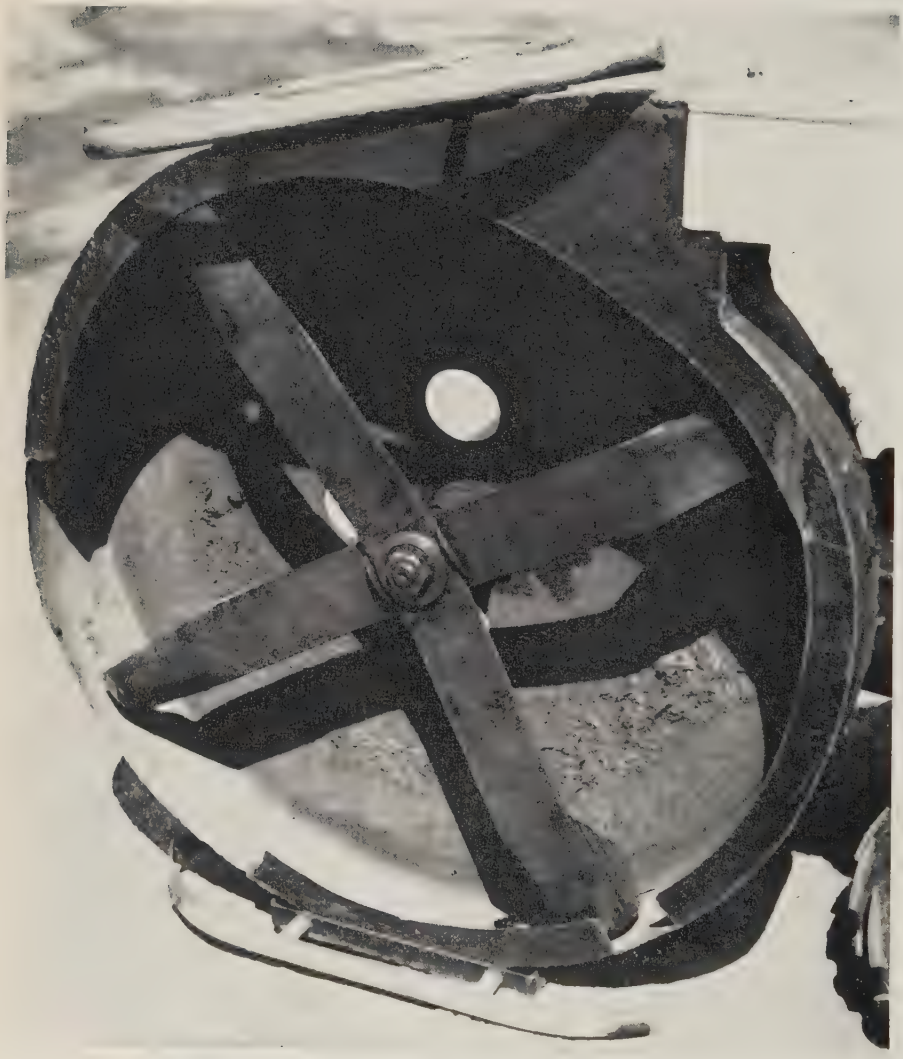


FIGURE 2. Detail of modifications made to the rotary mower housing cutter assembly.

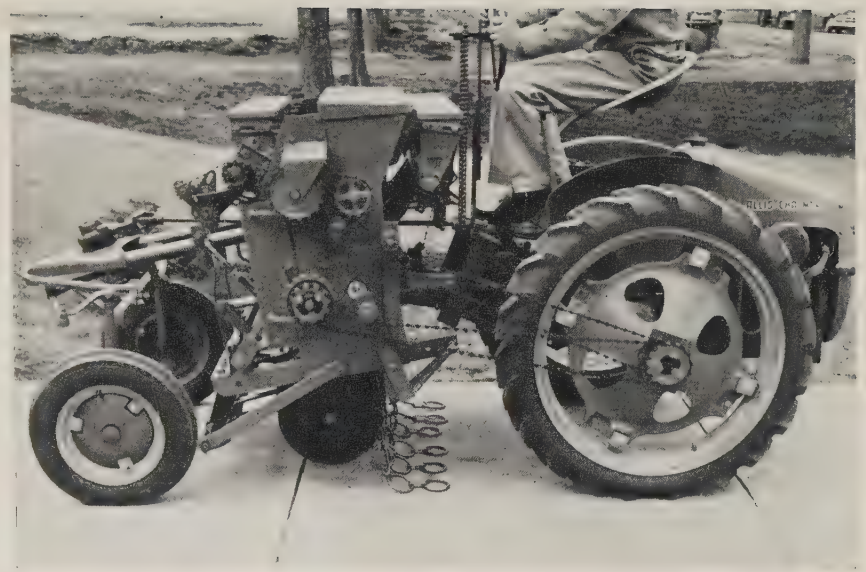


FIGURE 1.

(Right):
FIGURE 2.

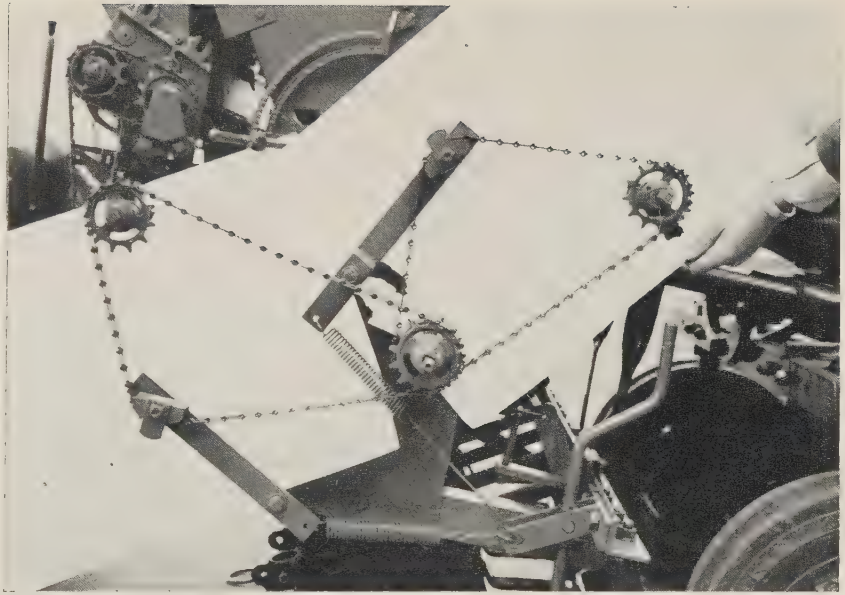
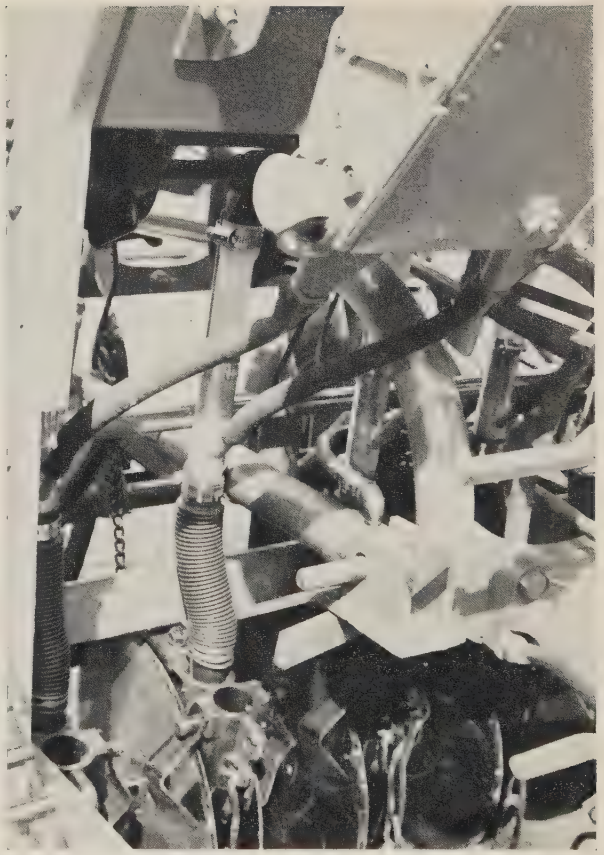


FIGURE 3.



(Right):
FIGURE 4.

The development of this machine should prove of value to investigators requiring moderate quantities of green forage material for feeding trials or pilot scale grass silage experiments. The modifications are practical, economical, and have been developed sufficiently that the unit could be readily constructed with assurance of adequately serving the above needs.

EQUIPMENT FOR SEEDING FERTILIZER EXPERIMENTS WITH SMALL GRAINS[1]

C. F. Bentley[2]

University of Alberta, Edmonton, Alta.

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Equipment for placing replicated, randomized fertilizer experiments with small grains poses problems in Alberta. Fertilizers should be placed in the drill runs with the seed, as that is farm practice. Speed of placing experiments is also important because of the short season and the high cost of labour. A convenient machine meeting these requirements has been assembled and used.

The equipment is mounted on an Allis-Chalmers Model G tractor which provides the power and frame. Ground rigs and a cut-down seed box from an Allis-Chalmers All-Crop drill have been fitted to the tractor. Six rows at 7-inch spacings are seeded. Two fertilizer attachments with positive-type feed mechanism and capable of independent or simultaneous operation have been attached. These Universal Fertilizer attachments are obtainable from the Consolidated Mining and Smelting Company, Calgary, Alberta. Chain drives from a rear tractor wheel operate the drill and fertilizer attachments (Figure 1). Copper adapters fitted to plastic extensions of seed tubes bring fertilizer from both attachments into the drill seed tubes (Figure 2). Fertilizer hoses can be disconnected from these tubes for other fertilizer placements. Two easily changed sprockets drive each attachment and determine the rate of fertilizer application (Figure 3).

Granulated fertilizers supplying nitrogen or phosphorus may be applied singly or in any combination at from 0 to 80 lb. of either nutrient per acre. Only granulated fertilizers can be used but, after calibrating the equipment, no weighing, packaging, or mixing of fertilizers is necessary when only two nutrients are concerned. The fertilizer boxes are easy to clean out; less than 5 minutes are required to change a fertilizer. The All-Crop drill shoe has two openings, enabling fertilizer placement with the seed or at seed depth but 3/8 inch from the seed (Figure 4). Thus two placements in relation to the seed and broadcast application are possible for the fertilizer in each attachment.

The drill ground rigs are raised by the tractor's hydraulic unit; the same action disengages the seed box and fertilizer attachment drives. Seed and fertilizer feeding start or stop with about 4 feet of travel after raising or lowering the drill ground rigs. Plots of any length exceeding 15 feet can be seeded. Broadcast fertilization of hay and pasture crops is equally convenient.

Advantages of the equipment, which is hauled in a 1-ton truck, are illustrated by the time required to place an experiment. In $4\frac{1}{2}$ hours two men have unloaded the machine, measured off an experimental area,

[1] Contribution from the Department of Soil Science, University of Alberta, Edmonton.

[2] Professor of Soil Science.

seeded a 25-treatment experiment with six replications in a balanced lattice design, staked the plots and reloaded the equipment. The plots were 3.5 feet by 20 feet, with a 15-foot roadway between blocks. The treatments included some fertilizer placements at 3/8 inch from the seed and some broadcast applications in addition to 16 combinations of nitrogen and phosphorus placed with the seed.

The equipment cost approximately $1,800. This included the labour and machine-shop expenses involved in designing and assembling the unit. Photographs showing further details of the machine and an expanded explanation of construction details are available at cost—$2.50 per set.

ACKNOWLEDGEMENT

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NOTE ON INJURY TO BLUEBERRY SPROUTS BY THE BLUEBERRY THRIPS, *FRANKLINIELLA VACCINII* MORGAN (THYSANOPTERA: THRIPIDAE)[1]

The blueberry thrips, *Frankliniella vaccinii* Morgan, has become in recent years a pest of low-bush blueberries in New Brunswick and Nova Scotia. Although Phipps (2) reported the species as a pest of blueberries in Maine as early as 1926, it was not found in New Brunswick until 1947. Since then, the thrips has been collected in blueberry fields from Charlotte County, N.B., to Yarmouth County, N.S.

In crop fields, leaves arising from infested buds do not unfold normally and leaf rolls resembling enlarged buds are formed. Terminal buds appear to be preferred by the thrips, and plants usually have only one or a few of these leaf rolls. In sprout fields, however, the leaves on infested plants are wrapped around the stems and the entire shoots are often enclosed within foliar jackets. Injured foliage in both stages of growth frequently turns reddish in colour and is very conspicuous in contrast to the deep green of uninfested plants. In crop fields the thrips infest the plants while the buds are opening in May and the leaf rolls are noticeable early in June. Injury to sprouts is apparent by the third week of June. Damage is usually concentrated in patches, a small amount of injury being found in the rest of the field.

Lathrop (1) has reported that the thrips (by injuring plants in crop fields) may cause difficulty in raking ripe berries and that in severe infestations the crop is materially reduced. This Note presents evidence of a severe reduction in crop as a result of injury to the blueberry sprouts.

In July, 1954, 100 thrips-injured sprouts in an infested field at Lynnfield, N.B., were tagged with small metal markers. In October these sprouts were examined and compared with uninfested sprouts. Bud growth was retarded on most of the infested sprouts and necrosis of the tips occurred on several plants on which stems were completely enclosed by injured leaves. Some plants had produced one or two new terminal twigs to replace the dead tips.

The marked plants were examined again in May, 1955, to determine the effects of the injury on the formation of fruit. As blossoms were forming it was possible to assess the loss in potential yield without the confounding effects of inadequate pollination and blossom blight. Six shoots were dead, 81 had no blossoms, and 13 had blossoms. Those plants with blossoms, however, had an average of only 6 per plant, or 76 per cent less than the average of 26 on uninfested plants. The potential yield of the infested plants was, therefore, reduced by 97 per cent. Winter mortality or some other factor may have been responsible for part of this reduction but the loss was chiefly due to the thrips infestation.

The evidence of loss in crop from attack by the thrips during the sprout year sheds new light on the extent of damage caused by this pest and demonstrates the need for control measures in sprout as well as crop fields.

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G. W. WOOD

Entomology Laboratory, Fredericton, N.B.

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[1] Contribution No. 3452, Entomology Division, Science Service, Dept. of Agriculture, Ottawa, Canada.

NOTE ON THE EXTRACTION OF ORGANIC MATTER FROM THE B HORIZON OF A PODZOL SOIL[1]

In order to evaluate the role of organic matter in the mobilization and subsequent precipitation of sesquioxides in the profile of podzol soils, its extraction from the B horizon, followed by its characterization and a study of its reactivity towards iron and aluminum, appears to be a rational approach. Recently, Martin and Reeve (4) reported on the use of a number of chelating agents for the extraction of organic matter from podzolic B horizons. Although considerable amounts of organic matter could be extracted, the main difficulty encountered was contamination of the soil organic matter by excess chelating agent which could not always be removed effectively. A number of workers (1, 2, 5) have used mixtures of dilute hydrochloric and hydrofluoric acids to dissolve large portions of mineral matter away from organic matter in order to purify the latter. Contrary to expectations it was found in the present investigation that cold dilute mixtures of hydrochloric and hydrofluoric acids extracted selectively a major portion of the organic matter in a podzol B horizon while bringing into solution only very small amounts from the Ao + A_1 horizon of the same soil. The experimental procedure was as follows:

The acids were prepared in dilute mixtures, in 1:1 proportions, and varying in concentration from 0.5 to 2.5 per cent (v/v) for each component. The mixtures were added in 100 ml. portions to plastic beakers each containing 2-gm. samples of soil ground to pass a 100-mesh sieve, stirred and allowed to stand at room temperature for 24 hours with occasional shaking. The supernatant liquid was then carefully siphoned off, centrifuged at 2000 r.p.m. for ten minutes to remove solids, and made up to 100 ml. The extraction was repeated twice with further 100 ml. portions of the acid mixture. Appropriate aliquots of the extract and portions of the residue were freeze-dried and analysed for total carbon by the manometric Van Slyke-Folch method (6), using the Van Slyke-Neill apparatus.

The profile belonged to the Armadale series, a podzol soil from Prince Edward Island. Preliminary work indicated that 0.50 per cent HCl-HF was more effective than either 1.25 per cent or 2.50 per cent HCl-HF in removing carbon from the A_3-B_{21} horizon of this profile. Water alone was very ineffective, removing only 0.7 per cent of the total carbon present. A study of the comparative extractive power of 0.5 per cent HCl and 0.5 per cent HF separately on this sample indicated that HF was considerably more effective than HCl in removing carbon.

Table I shows analytical data for the various horizons of the Armadale profile. The distribution of the free iron and aluminum oxides as determined by the method of Mackenzie (3) is also presented.

The data suggest the use of 0.5 per cent HCl-HF for the extraction of that "type" of organic matter active in podzolization. Besides organic matter, appreciable amounts of iron and aluminum were extracted by the acid mixture. Addition of enough ethyl alcohol to the extract, adjusted to pH 3.0, to give a 50 per cent (v/v) concentration, caused complete

[1] Contribution No. 329, Chemistry Division, Science Service, Canada Department of Agriculture, Ottawa

TABLE 1.—SOME CHARACTERISTICS OF THE ARMADALE PROFILE (RESULTS IN MG. PER G. OF AIR-DRY SOIL)

Horizon	C in soil	C in extract*	% C extracted	Colour of extract	"Free" Fe_2O_3 in soil	"Free" Al_2O_3 in soil
Ao + A_1	352.0	7.0	2	very faint yellow	6.30	0.94
A_2	2.0	0.6	30	colourless	3.88	0.56
A_3 – B_{21}	41.7	29.0	70	reddish brown	9.10	10.68
B_{22}	26.7	24.5	92	reddish brown	17.98	13.46
B_{23}	8.5	7.5	88	light yellow	17.58	9.08
C	1.3	0.65	50	colourless	14.42	3.36

*0.5% (v/v) HCl-HF.

coagulation of all organic matter, iron and aluminum, as indicated by tests on the supernatant liquid. Furthermore, the known complexing power of the fluoride ion for both iron and aluminum suggests that iron- and aluminum-organic matter complexes were extracted. The use of 0.5 per cent HF as extractant is at present under investigation. A more detailed account will be published at a later date.

ACKNOWLEDGEMENT

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M. SCHNITZER
J. R. WRIGHT
Chemistry Division,
Science Service,
Ottawa, Canada.

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ABBREVIATIONS FOR TITLES OF PUBLICATIONS

The Editorial Board has recommended that the *Chemical Abstracts* system of abbreviations be used in the list of references presented with each paper published in the Institute's "Journal" series. In order to assist authors in obtaining the correct abbreviations, the Board has decided to publish the following list, which includes those periodicals—about 220 in number—to which reference has been made more than once in papers published in the last three or four volumes of the Journal. Furthermore, it was considered advisable to present the names of the provinces of Canada and of the states of the United States of America, as well as a selected list of words, for use in referring to bulletins, circulars and miscellaneous publications.

Title of Periodical	*Abbreviation*
Acta Agriculturae Scandinavica	Acta Agr. Scand.
Acta Agriculturae Suecana	Acta Agr. Suecana
Acta Chemica Scandinavica	Acta Chem. Scand.
Acta Physiologica Scandinavica	Acta Physiol. Scand.
Agricultural Chemicals	Agr. Chemicals
Agricultural Engineering. London.	Agr. Eng. London
Agricultural Institute Review	Agr. Inst. Rev.
Agriculture (England)	Agriculture (Engl.)
Agronomy Journal	Agron. J.
American Bee Journal	Am. Bee J.
American Fertilizer	Am. Fertilizer
American Journal of Botany	Am. J. Botany
American Journal of Hygiene	Am. J. Hyg.
American Journal of Physiology	Am. J. Physiol.
American Journal of Public Health	Am. J. Public Health
American Mineralogist	Am. Mineralogist
American Naturalist	Am. Naturalist
American Paint Journal	Am. Paint J.
American Potato Journal	Am. Potato J.
Analyst	Analyst
Analytical Chemistry	Anal. Chem.
Annales de l'ACFAS	Ann. ACFAS
Annals of Applied Biology	Ann. Appl. Biol.
Annals of Botany. London	Ann. Botany (London)
Annals of Mathematical Statistics	Ann. Math. Statistics
Annals of the Royal Agricultural College of Sweden	Ann. Roy. Agr. Coll. Sweden
Annual Report of the Agricultural and Horticultural Research Station, Long Ashton, Bristol	Ann. Rept. Agr. and Hort. Research Sta., Long Ashton, Bristol
Annual Report, East Malling Research Station, Kent	Ann. Rept. East Malling Research Sta., Kent
Annual Report of the Entomological Society of Ontario	Ann. Rept. Entomol. Soc. Ontario
Annual Report of the Secretary of the State Horticultural Society of Michigan	Ann. Rept. Secy. State Hort. Soc. Mich.
Arbeiten aus des biologischen Reichsanstalt für Land- und Forstwirtschaft, Berlin-Dahlem	Arb. biol. Reichsanstalt Land- u. Forstwirtsch., Berlin-Dahlem.
Archives of Biochemistry and Biophysics	Arch. Biochem. and Biophys.
Arctic	Arctic
Australian Journal of Agricultural Research	Australian J. Agr. Research
Australian Journal of Experimental Biology and Medical Science	Australian J. Exptl. Biol. Med. Sci.

Title of Periodical	*Abbreviation*
Bacteriological Reviews	Bacteriol. Revs.
Bee World	Bee World
Beiträge zur Agrarwissenschaft	Beitr. Agrarwiss.
Berichte der deutschen chemischen Gesellschaft	Ber. deut. chem. Ges.
Better Crops with Plant Food	Better Crops with Plant Food
Bibliographia genetica	Bibliographia genetica
Biochemical Journal (London)	Biochem. J. (London)
Botanical Gazette	Botan. Gaz.
Botanical Review	Botan. Rev.
British Journal of Experimental Pathology	Brit. J. Exptl. Pathol.
British Journal of Nutrition	Brit. J. Nutrition
Bulletin of Entomological Research	Bull. Entomol. Research
Bulletin of the Imperial (Commonwealth) Bureau of Pastures and Field Crops	Bull. Imp. (Commonwealth) Bur. Pastures, Field Crops
Canada Department of Trade and Commerce, Board of Grain Commissioners, Grain Research Laboratory Annual Report	Can. Dept. Trade and Commerce, Board Grain Commissioners Grain Research Lab. Ann. Rept.
Canadian Entomologist	Can. Entomologist
Canadian Journal of Agricultural Science	Can. J. Agr. Sci.
Canadian Journal of Botany	Can. J. Botany
Canadian Journal of Chemistry	Can. J. Chem.
Canadian Journal of Comparative Medicine and Veterinary Science	Can. J. Comp. Med. Vet. Sci.
Canadian Journal of Research	Can. J. Research
Canadian Journal of Technology	Can. J. Technol.
Cellulosechemie	Cellulosechemie
Cereal Chemistry	Cereal Chem.
Chemical Abstracts	Chem. Abstr.
Chemist Analyst	Chemist Analyst
Comptes rendus des séances de la société de biologie et de ses filiales	Compt. rend. soc. biol.
Comptes rendus hebdomadaires des séances de l'académie d'agriculture de France	Compt. rend. acad. agr. France
Comptes rendus (Doklady) de l'académie des sciences de l'U.R.S.S.	Compt. rend. acad. sci. U.R.S.S.
Contributions. Boyce Thompson Institute for Plant Research	Contribs. Boyce Thompson Inst.
Crops and Soils	Crops and Soils
Cytologia (Tokyo)	Cytologia (Tokyo)
Dairy Science Abstracts	Dairy Sci. Abstr.
Down to Earth	Down to Earth
Ecology	Ecology
Economic Proceedings of the Royal Dublin Society	Econ. Proc. Roy. Dublin Soc.
Empire Journal of Experimental Agriculture	Empire J. Exptl. Agr.
Endocrinology	Endocrinology
Experiment Station Record	Expt. Sta. Record
Federation Proceedings	Federation Proc.
Feedstuffs	Feedstuffs
Fertilizer and Feeding Stuffs Journal	Fertilizer and Feeding Stuffs J.
Food Research	Food Research
Food Technology	Food Technol.
Forestry Chronicle	Forestry Chron.
Genetica agraria	Genet. agrar.
Genetics	Genetics
Geographical Review	Geograph. Rev.
Gleanings in Bee Culture	Gleanings in Bee Culture

Title of Periodical	*Abbreviation*
Herbage Reviews	Herbage Revs.
Hereditas (Genetiskt Arkiv)	Hereditas
Hilgardia	Hilgardia
Indian Journal of Agricultural Science	Indian J. Agr. Sci.
Indian Journal of Veterinary Science and Animal Husbandry	Indian J. Vet. Sci.
Industrial and Engineering Chemistry	Ind. Eng. Chem.
Industrial and Engineering Chemistry, Analytical Edition	Ind. Eng. Chem. Anal. Ed.
International Dairy Congress, Proceedings	Intern. Dairy Congr. Proc.
Iowa State College Journal of Science	Iowa State Coll. J. Sci.
Japanese Journal of Botany	Japan. J. Botany
Japanese Journal of Genetics	Japan. J. Genet.
Journal of Agricultural and Food Chemistry	J. Agr. Food Chem.
Journal of Agricultural Research	J. Agr. Research
Journal of Agricultural Science	J. Agr. Sci.
Journal of the American Chemical Society	J. Am. Chem. Soc.
Journal of the American Society of Agronomy	J. Am. Soc. Agron.
Journal of the American Veterinary Medical Association	J. Am. Vet. Med. Assoc.
Journal of Animal Science	J. Animal Sci.
Journal of the Association of Official Agricultural Chemists	J. Assoc. Offic. Agr. Chemists
Journal of the Australian Institute of Agricultural Science	J. Australian Inst. Agr. Sci.
Journal of Bacteriology	J. Bacteriol.
Journal of Biological Chemistry	J. Biol. Chem.
Journal of the British Grassland Society	J. Brit. Grassland Soc.
Journal of the Chemical Society	J. Chem. Soc.
Journal of the Council for Scientific and Industrial Research	J. Council Sci. Ind. Research
Journal of Dairy Research	J. Dairy Research
Journal of Dairy Science	J. Dairy Sci.
Journal of the Department of Agriculture of South Australia	J. Dept. Agr. S. Australia.
Journal of the Department of Agriculture of Western Australia	J. Dept. Agr. W. Australia.
Journal of Economic Entomology	J. Econ. Entomol.
Journal of Experimental Biology	J. Exptl. Biol.
Journal of Forestry	J. Forestry
Journal of General Microbiology	J. Gen. Microbiol.
Journal of Genetics	J. Genet.
Journal of Heredity	J. Heredity
Journal of Horticultural Science	J. Hort. Sci.
Journal of Hygiene	J. Hyg.
Journal of Laboratory and Clinical Medicine	J. Lab. Clin. Med.
Journal of Milk Technology	J. Milk Technol.
Journal of Milk and Food Technology	J. Milk and Food Technol.
Journal of the Ministry of Agriculture	J. Ministry Agr.
Journal of Nutrition	J. Nutrition
Journal of Pharmacology and Experimental Therapeutics	J. Pharmacol. Exptl. Therap.
Journal of Physiology (London)	J. Physiol. (London)
Journal of Pomology and Horticultural Science	J. Pomol. Hort. Sci.
Journal of Range Management	J. Range Management
Journal of the Royal Horticultural Society	J. Roy. Hort. Soc.
Journal of the Science of Food and Agriculture	J. Sci. Food Agr.
Journal of Scientific Instruments	J. Sci. Instr.
Journal of the Society of Chemical Industry (London)	J. Soc. Chem. Ind. (London)
Journal of Soil Science	J. Soil Sci.
Journal of the Textile Institute	J. Textile Inst.
Journal of the Washington Academy of Sciences	J. Wash. Acad. Sci.

Title of Periodical	*Abbreviation*
Kungliga Lantbruks-Högskolans Annaler	Kgl. Lantbruks-Högskol. Ann.
Kungliga Lantbrukshogskolan och Statens Lantbruksförsök. Statens Husdjursförsök Meddelande	Kgl. Lantbrukshögsköl. och Statens Lantbruksförsök. Statens Husdjursförsök Medd.
Landbouwkundig Tijdschrift	Landbouwkund. Tijdschr.
Landwirtschaftlichen Versuchs-Stationen	Landwirtsch. Vers.-Sta.
Mededelingen van de Landbouwhogeschool te Wageningen.	Mededel. Landbouwhogeschool. Wageningen
Milk Plant Monthly	Milk Plant Monthly
Monthly Weather Review. Toronto	Monthly Weather Rev. Toronto
Mosquito News	Mosquito News
Mycologia	Mycologia
Nature (London)	Nature
Naunyn-Schmiedeberg's Archiv für experimentelle Pathologie und Pharmakologie	Naunyn-Schmiedeberg's Arch. exptl. Pathol. Pharmakol.
New Phytologist	New Phytologist
New Zealand Journal of Agriculture	New Zealand J. Agr.
New Zealand Journal of Science and Technology	New Zealand J. Sci. Technol.
Nutrition Abstracts and Reviews	Nutrition Abstr. & Revs.
Ohio Journal of Science	Ohio J. Sci.
Oléagineux	Oléagineux
Onderstepoort Journal of Veterinary Science and Animal Industry	Onderstepoort J. Vet. Sci. Animal Ind.
Paper Trade Journal	Paper Trade J.
Parasitology	Parasitology
Physiological Reviews	Physiol. Revs.
Phytopathologische Zeitschrift	Phytopathol. Z.
Phytopathology	Phytopathology
Plant and Soil	Plant and Soil
Plant Disease Reporter	Plant Disease Reptr.
Plant Physiology	Plant Physiol.
Poultry Science	Poultry Sci.
Proceedings. American Society for Horticultural Science	Proc. Am. Soc. Hort. Sci.
Proceedings. American Society for Sugar Beet Technologists	Proc. Am. Soc. Sugar Beet Technol.
Proceedings of the Canadian Phytopathological Society	Proc. Can. Phytopathol. Soc.
Proceedings of the Entomological Society of British Columbia	Proc. Entomol. Soc. Brit. Columbia
Proceedings of the Helminthological Society of Washington, D.C.	Proc. Helminthol. Soc. Wash., D.C.
Proceedings of the International Congress of Pure and Applied Chemistry	Proc. Intern. Congr. Pure and Appl. Chem.
Proceedings of the International Congress of Soil Science	Proc. Intern. Congr. Soil Sci.
Proceedings of the International Dairy Congress	Intern. Dairy Congr. Proc.
Proceedings of the International Grassland Congress	Proc. Intern. Grassland Congr.
Proceedings of the Linnean Society of New South Wales	Proc. Linnean Soc. N.S. Wales
Proceedings of the National Academy of Sciences of the United States of America.	Proc. Natl. Acad. Sci. U.S.
Proceedings of the New Zealand Society of Animal Production	Proc. New Zealand Soc. Animal Prod.

Title of Periodical	*Abbreviation*
Proceedings of the Northeastern Weed Control Conference	Proc. Northeast. Weed Control Conf.
Proceedings of the Royal Irish Academy	Proc. Roy. Irish Acad.
Proceedings of the Royal Society (London)	Proc. Roy. Soc. (London)
Proceedings of the Royal Society of Victoria.	Proc. Roy. Soc. Victoria
Proceedings of the Society for Applied Bacteriology	Proc. Soc. Appl. Bacteriol.
Proceedings of the Society for Experimental Biology and Medicine	Proc. Soc. Exptl. Biol. Med.
Proceedings. Soil Science Society of America	Soil Sci. Soc. Amer. Proc.
Proceedings of the Annual Meeting of the Washington State Horticultural Association	Proc. Wash. State Hort. Assoc.
Proceedings of the World's Poultry Congress and Exposition	Proc. World's Poultry Congr.
Public Roads	Public Roads
Pulp & Paper Magazine of Canada	Pulp & Paper Mag. Can.
Report of the Alfalfa Conference	Rept. Alfalfa Conf.
Report of the Board of Grain Commissioners, Canada.	Rept. Board Grain Comm. Can.
Report. Canadian Horticultural Council	Rept. Can. Hort. Council
Report of the Canadian Plant Disease Survey	Rept. Can. Plant Disease Survey.
Report of the Quebec Society for the Protection of Plants	Rept. Quebec Soc. Protection Plants
Research Studies of the State College of Washington	Research Studies State Coll. Wash.
Review of Applied Mycology	Rev. Appl. Mycol.
Rhodora	Rhodora
Science	Science
Scientific Agriculture	Sci. Agr.
Scientific Monthly	Sci. Monthly
Scientific Proceedings of the Royal Dublin Society	Sci. Proc. Roy. Dublin Soc.
Seed World	Seed World
Soap and Sanitary Chemicals	Soap Sanit. Chemicals
Soil Science	Soil Sci.
Soybean Digest	Soybean Dig.
Stain Technology	Stain Technol.
Technical Communication. Imperial Bureau of Fruit Production. East Malling	Tech. Commun. Bur. Fruit Prod., E. Malling
Technical Communication. Imperial. (Commonwealth) Bureau of Horticulture and Plantation Crops. East Malling	Tech. Commun. Bur. Hort. E. Malling
Technical Communication. Imperial (Commonwealth) Bureau of Soil Science. Harpenden	Tech. Commun. Bur. Soil Sci. Harpenden
Tidsskrift for Planteavl	Tidsskr. Planteavl
Tijdschrift over Plantenziekten	Tijdschr. Plantenziekten
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Transactions of the Royal Society of Canada	Trans. Roy. Soc. Can.
Zeitschrift für angewandte Entomologie	Z. angew. Entomol.
Zeitschrift für induktive Abstammungs- und Vererbungslehre	Z. indukt. Abstamm- u. Vererblehre
Zeitschrift für Naturforschung	Z. Naturforsch.

Title of Periodical	*Abbreviation*
Zeitschrift für Pflanzenkrankheiten (Pflanzenpathologie) und Pflanzenschutz	Z. Pflanzenkrankh. Pflanzenschutz
Zeitschrift für Pflanzenzüchtung	Z. Pflanzenzücht.
Zeitschrift für Tierzüchtung und Züchtungsbiologie	Z. Tierzücht. Züchtungsbiol.
Zeitschrift für Untersuchung der Nahrungs- und Genussmittel	Z. Untersuch. Nahr.- u. Genussm.
Zentralbaltt für Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene	Zentr. Bakteriol. Parasitenk.
Züchter	Züchter

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Kentucky	Kentucky
Louisiana	Louisiana
Maine	Maine
Maryland	Maryland
Massachusetts	Mass.
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Minnesota	Minnesota or Minn.
Mississippi	Mississippi
Missouri	Missouri
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Nevada	Nevada
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North Dakota	N. Dakota
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South Dakota	S. Dakota
Tennessee	Tenn.
Texas	Texas
Utah	Utah
Vermont	Vermont
Virginia	Virginia
Washington	Wash.
West Virginia	West Va.
Wisconsin	Wisconsin or Wis.
Wyoming	Wyoming or Wyo.

Miscellaneous

Advisory	Advisory
Agriculture, agricultural	Agr.
Animal	Animal
Annual	Annual
Association	Assoc.
Bi-monthly	Bi-monthly
Bulletin	Bull.
Bureau	Bur.
Chemical	Chem.
Circular	Circ.
College	Coll.
Committee	Comm.
Conference	Conf.
Conservation	Conservation
Council	Council
Department	Dept.
Division	Div.
Engineering	Eng.
Experiment	Expt.
Experimental	Exptl.
Extension	Extension
Faculty	Faculty
Fertilizer	Fertilizer
Forestry	Forestry
Geology, geological	Geol.
Handbook	Handb.
Industry, industrial	Ind.
Information	Information
Leaflet	Leaflet
Memoir (s)	Mem.
Meteorological	Meteor.
Methods	Methods
Mimeographed	Mimeographed
Miscellaneous	Misc.
Monograph	Monograph
Monthly	Monthly
National	Natl.
News Letter	News Letter
Pamphlet	Pamphlet
Press Bulletin	Press Bull.
Progress	Progress
Publication	Publ.
Public Health	Pub. Health
Quarterly	Quart.
Regional	Regional
Report	Rept.
Research	Research
Review	Rev.
Scientific	Sci.
Series	Ser.
Service	Service
Standard	Standard
State	State
Station	Sta.
Statistics	Statistics
Substation	Substa.
Supplement	Suppl.
Survey	Survey
Technical	Tech.
University	Univ.
Yearbook	Yearbook

NOTES TO CONTRIBUTORS

1. *General*

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   (a) The style and arrangement should conform to the usage of this journal. Reference may also be made to Canadian Government Style Manual.

   (b) An abstract of not more than 200 words, indicating the scope of the work and the principal findings, is required. The abstract should be in the same language as the main text.

   (c) Main sections of the paper will preferably include "Introduction", "Materials and Methods", "Experimental Results", "Discussion" and "Conclusions". A summary will usually be unnecessary.

   (d) Manuscripts must be typewritten, double-spaced, on white paper with liberal margin space. The original and two copies, mailed flat, are required. One copy will be returned to the author.

   (e) Each table should be typed on a separate sheet and should carry a number and title. All tables should be referred to in the text and desired position indicated.

   (f) Literature reviews should be limited to only the most pertinent references. References should be listed alphabetically by authors' names and numbered in that order. Each reference should have a corresponding key number in the text. References other than published papers, e.g., correspondence, unpublished manuscripts, etc., should be shown as foot-notes. Abbreviations should be according to the style used in *"Chemical Abstracts"*.

3. *Illustrations*

   (a) Photographs should be glossy prints, of size and clarity to give good reproduction.

   (b) Line drawings should be made with india ink on white drawing paper, blue tracing linen or co-ordinate paper ruled in blue only; any co-ordinate lines that are to appear in the reproduction should be ruled in black ink. The size should be not more than twice the linear dimensions of the type page in this journal. Letters and numerals should be in india ink and of such a size that they will be legible and not less than one millimetre in height when reproduced in a cut 3 inches wide. The original drawings must be submitted and preferably accompanied by a set of photographs thereof.

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M. l'Abbé Joseph Diament, Directeur, Ecole Superieure d'Agriculture, Ste. Anne de la Pocatière, Que.
H. G. Dion, Vice-Principal, Macdonald College of McGill University, Macdonald College, Que.
B. A. Eagles, Dean, Faculty of Agriculture, University of British Columbia, Vancouver, B.C.
N. H. Grace, Director, Research Council of Alberta, Edmonton, Alta.
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A. G. McCalla, Dean, Faculty of Agriculture, University of Alberta, Edmonton, Alta.
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J. R. Weir, Dean, Faculty of Agriculture, University of Manitoba, Winnipeg, Man.
Frank E. Wolff, General Agricultural Agent, Canadian Pacific Railway, Toronto, Ont.

In addition to the above regularly designated members of the committee, other Canadian technical officers are called to act as members in conference as required by the problems under consideration.

Edmond Cloutier, C.M.G., O.A., D.S.P., Queen's Printer and Controller of Stationery, Ottawa, 1956.